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TROPICAL FUSARIA [1]

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SIX PLATES AND FORTY-SEVEN TEXT FIGURES

INTRODUCTION

The lack of knowledge in regard to species of *Fusarium* has made it almost impossible to state their actual distribution. An understanding of this condition is absolutely essential, from a pathological standpoint especially, for the determination of the protective or control measures to be instituted. If it is known, for instance, that disease-producing fusaria are not present in new lands to be planted to various crops, the question of preventing the introduction of the disease-producing strain is a vital one. On the other hand, wild, saprophytic soil strains, closely related to known pathogenic species, may be present in the soil, and it may be that the former can eventually, by a gradual process, develop the parasitic qualities necessary to produce disease. It is then the work of the plant breeder to develop new disease-resistant strains or varieties of plants to prevent infection by soil fungi.

While Reinking was conducting an investigation in regard to the distribution of the banana-wilt organism (*Fusarium*

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cubense) in relation to banana culture, isolations of fusaria were made from the soil, and from banana and other plants, living and dead, in banana plantations and in the forest. Some five hundred fifty pure cultures of fusaria were obtained from all of these possible sources in banana lands of Honduras and Guatemala. After a detailed morphological study of these strains had been made, the number was finally reduced to some two hundred fifty, which still included a large number of identical species occurring on different hosts. These cultures were used as the basis for a joint investigation by us, working in the United States.[2] In these studies we were able to make comparisons with all the most-important strains of fusaria present in the United States and Europe. Forty-eight different fusaria were found to be present in the entire tropical collection. These comprise species of all but three sections of the subgenus *Fusarium*, and include perfect forms belonging to *Hypomyces, Calonectria, Gibberella*, and *Nectria*, of the Hypocreales. Fourteen fusaria were found to be new; namely, seven species, six varieties, and one form.(15)

The majority of the fungi described belong to sections that have parasitic species causing wilts, rots, and decays. For the greater part the parasitic nature of the species discussed still remains to be determined.(7) Whenever possible, the pathogenicity of each has been indicated. Investigations carried on in various parts of the world have already established the parasitic nature of species in some sections. In sections *Gibbosum* and *Roseum* are found species that cause fruit rots. The species in section *Liseola* (including *Fusarium moniliforme*, the cause of corn-mold disease) and related species are very abundant in the Tropics. The last-mentioned strains may quite possibly be found to produce disease in plants. No representatives of section *Discolor* were isolated in these studies, but it is known that some of these produce scab and blight of cereals grown in various parts of the world. Almost all of the known species of section *Elegans*, regarded as the cause of wilt disease, have been found in tropical soils. These were found in the main to be closely related, especially *F. cubense*, with the *oxysporum* group. Those isolated in the present investigations include *F. cubense* (banana wilt), *F. oxysporum* (potato wilt), *F. oxysporum* var. *nicotianae* (tobacco wilt) (see footnote 9,

[2] These studies were made during and after the Fusarium Conference held at Madison, Wisconsin, from June to August, 1924.

page 192), *F. aurantiacum* (wilt of Cucurbitaceæ), and *F. bulbigenum* (wilt of bulbs).(13) The question whether or not these species collected in tropical soils may cause a wilt on their principal host remains to be proved. They may be wild, saprophytic soil forms of the proved parasites, requiring decades or even longer periods for gradual adaptation to cultivated plants of a tendency to assume semiparasitic habits. Some of the species in section *Martiella* are known to produce tuber, stem, and root rots of plants. The tropical collection made of fusaria of the *Martiella* section is significant, in that it shows that practically all known species are found in the soil. Heretofore these organisms have been isolated primarily from decaying plant material of various kinds. The morphological and physiological studies clearly prove that the various species retain their identity, even when isolated from the soil and not from a particular host plant.

By the differentiation of the species isolated in these studies it has been shown that some have a larger range of hosts and a greater geographical distribution than was formerly known. Other species apparently were determined to be more or less restricted to special hosts. The fact that a large number of the species of fusaria have been found in various parts of the world, including the Tropics, indicates that their distribution in general is world-wide. The geographical location need not cover the parasitic nature; it may be found that some species are parasitic in one country and not in another. The necessity for systematic inoculation studies by various investigators on different plants is evident.(7)

SOURCES AND METHODS OF ISOLATION

The organisms described were isolated from various sources with a view of obtaining a representative fusaria flora of banana plantations and of new forest lands to be planted with bananas. Isolations were made from wilt-diseased banana plants, from bananas with other types of disease, from banana trash, from other plants in banana plantations, in lands being prepared for banana plantations, or in virgin forests. Extensive soil isolations were conducted from soil in banana plantations and in the forest. Isolations were also made from the air to determine the prevalence of air-borne spores. The distribution of each of the various species is given under habitat in the general description.

After conducting an extensive study for determination of the best methods of isolation of soil fusaria and those growing on or within plant material, one general method was finally employed. Almost all fusaria grow well under rather high acid conditions; consequently, acid media were chiefly employed. Checks on the use of acid media were continually made by using nonacid media to determine whether or not certain uncommon types of fusaria were being overlooked. Most often ordinary acidified potato agar was used for isolation purposes.

The method of soil isolation adopted was to place a small amount of soil to be tested into a sterile Petri dish and add 1 to 2 cubic centimeters of a 2 per cent sterilized lactic acid solution. The plate was then poured with 10 cubic centimeters of potato agar and the soil particles separated by carefully rotating the dish. The acid inhibits all bacterial growth, but at the same time does not prevent the growth of any *Fusarium* that may be present. As soon as a fungus growth developed the plate was examined under the microscope by removing the cover of the Petri dish and placing the open dish on the microscope stage. Examination was made for fusaria spores and typical mycelial growth. An investigator soon becomes acquainted with the fusaria growth and can readily pick out the colonies. At this stage many other fungi are also present, especially various strains of molds. The colony of *Fusarium*, or as nearly a pure portion of it as possible, was then transferred to a tube of potato agar. The *Fusarium* will develop along with, but separately from, any other fungus that may be present. After a day or so of growth in the tube, the fusarial development and spores therefrom were transferred to a sterile water blank, shaken up thoroughly, and a poured dilution plate culture of one loopful of the same prepared. The *Fusarium* spores were in this way separated from any other spores that may have been present, and pure cultures of the various strains that developed were obtained. The original plates, with the soil, were always retained for later examination so that slow-growing strains of fusaria might not be overlooked. This method works splendidly with all fusaria that produce spores. Occasionally strains are found that primarily produce mycelium; these can generally be separated from other fungi by making transfers of the mycelium from portions of the growth that apparently is free from other organisms.

The isolation of fusaria from plant material was done by plating out a portion of the material, supposed to contain a

Fusarium, by means of a sterilized, flamed scalpel, on a plate of potato agar to which had been added 1 cubic centimeter of a 2 per cent sterilized lactic acid solution (Plate 4, fig. 5). The acid need not be added, but it inhibits all bacterial growth and at the same time does not prevent the development of the fusaria. As soon as a pure growth of *Fusarium* developed a portion was transferred to a tube of potato agar. If a pure culture could not be obtained directly from the resulting growth, the poured plate procedure for separation of fusaria from other fungi as discussed under the soil isolation method was employed.

MORPHOLOGICAL AND PHYSIOLOGICAL STUDIES

The morphological and physiological studies with the various strains were conducted according to the methods described in former papers. (1, 2, 9, 10, 11, 12, 14) Since the details regarding the criteria of the norm, the production of the norm, the use of various culture media, and the effect of other physiological factors have been fully discussed in these papers and especially summarized in one, (14) they need not be taken up here in detail. It might be well, however, to emphasize certain important points.

In the identification of species it is essential that a uniform method of procedure be followed. For proper determinations it is important to have different types of media in order to obtain the complete range of spore forms of a particular strain. It frequently may happen that somewhat different spore types are produced from different kinds of growth such as mycelium, pionnotes, or sporodochia. Sometimes, spores of particular species (*Fusarium cubense*) may have slenderer and longer spores in pionnotal masses than when produced from the mycelium or in older sporodochial masses. At least three good media are generally necessary for the production of the normal types. Oatmeal agar or potato agar, rice, and *Melilotus* or *Alnus* stems will generally give the requirements for a comprehensive study. These give, more or less, a range of natural conditions for growth of fusaria. Rice cultures in general will be found very helpful in grouping the fusaria into their respective sections according to the color reaction, although it must be remembered that color production is secondary to morphology. Ordinary potato-agar plate cultures (Plate 4, figs. 1 to 5) are frequently found useful in distinguishing between certain strains.

In studying the fungi under various climatic conditions, it has been found that the time required for production of normal spores varies. Under tropical influence normal spore production gen-

erally takes less time than in the temperate regions. The descriptions of the various fusaria as they grew on hard potato agar, potato-tuber plug, corn stalks, green bean pods, banana peel, and banana-fruit flesh were obtained from the fungus growth under tropical conditions. The range of temperature during these studies was between 17 and 31° C., with an average of approximately 25° C. The relative humidity ranged between 77 and 91, with an average of 84.5. The physiological studies on oatmeal agar, potato agar, plus 5 per cent glucose, rice, and *Melilotus* and *Alnus* stems were made in the Temperate Zone where the room temperature ranged from 21.5 to 25.5° C., with an average of 22.5° C. The cultures growing in the Tropics were kept in diffused light such as would normally be present in a screen-wire cabinet. Those grown in the temperate region were more fully exposed to the light, having been kept on tables under the general laboratory light conditions. No special precautions were taken to obtain nonsoluble glassware, even though it was known that a variation in color may be produced by chemicals, especially soluble alkalies, in the glass tubes. Minor changes in color character are not regarded as sufficient to modify the identification.

The morphological and physiological studies are summarized in the description of genera, species, varieties, and forms. A technical description is given of the fungus, the habitat, the growth characters on various media, and the measurements of conidia on different media and an average of these measurements. The measurements of conidia on different media, especially when the spores were taken from different sources, such as mycelium, pionnotes, or sporodochia, are significant in that they point out the possible differences that may arise within the same species when normal spores are produced under various conditions.(14) The averages of these measurements give the average normal type, but need not necessarily clearly indicate the average size of different types as grown upon different media and under different sporulation conditions. For accurate determinations the average size of different types grown under their particular conditions is extremely important, and comparison should only be made of conidia produced under like circumstances.

In the study of the various species under a particular section it is found that one species gradually merges into the next higher in scale, starting from the small-spore types and running

up to the larger-spore types. A gradual evolution of the fusaria is here represented. This fact is often at first confusing in identifying fusaria; but, after a detailed morphological and physiological study has been conducted, it is found that there are certain distinct types that have been set apart to represent distinct species. Slight differences between different strains of the same species necessarily occur, ranging from the smallest type of spore to the largest within the species. This variation is only natural and what an investigator should expect. Because of this slight variation the temptation to classify new varieties is great and should be guarded against. The same difficulties are found in a systematic, taxonomic study of other members of the plant kingdom and merely represents a gradual evolution that has been taking place during the past hundreds of years. This evolution is clearly shown in the presentation of the various species under each section in the present paper, and is especially evident in section *Martiella*.

In giving the color descriptions of fungi on various media, the color standard and color nomenclature of Ridgway(8) were followed. Dried specimens and pure cultures of each strain of *Fusarium* have been placed in the herbarium of the mycological collection of the Bureau of Plant Industry, United States Department of Agriculture, for permanent preservation. Pure cultures of the fusaria new to science have been deposited with the Centraal Bureau voor Schimmelcultures, Baarn, Holland.

SYSTEMATIC ARRANGEMENT OF THE SPECIES OF FUSARIUM

The systematic arrangement of the species of *Fusarium* into sections, followed in the presentation, is according to the grouping of fusaria into sections as agreed upon at the general Fusarium Conference held at Madison, Wisconsin, June to August, 1924.(14) The species, varieties, and forms discussed under each section have been arranged according to the size of the spores, starting with the smaller type and ending with the larger type. All drawings in the text figures, unless otherwise stated, have been prepared to a uniform magnification of 1:1000.

LIST OF FUSARIA

I. Section *Eupionnotes* Wollenweber.
Subsection *Chlamydospora* Wollenweber.
1. *Fusarium pusillum* Wollenweber.
2. *Fusarium dimerum* Penzig.

III. Section *Sporotrichiella* Wollenweber.
3. *Fusarium chlamydosporum* Wollenweber and Reinking.
V. Section *Arthrosporiella* Sherbakoff.
4. *Fusarium semitectum* Berkeley and Ravenel.
5. *Fusarium camptoceras* Wollenweber and Reinking.
6. *Fusarium incarnatum* (Robinson) Saccardo.
7. *Fusarium diversisporum* Sherbakoff.
8. *Fusarium anguioides* Sherbakoff.
VI. Section *Gibbosum* Wollenweber.
9. *Fusarium bullatum* Sherbakoff var. *minus* Wollenweber and Reinking.
10. *Fusarium bullatum* Sherbakoff var. *brevius* Wollenweber and Reinking.
11. *Fusarium bullatum* Sherbakoff.
12. *Fusarium ossicolum* (Berkeley and Curtis) Saccardo.
13. *Fusarium falcatum* Appel and Wollenweber.
14. *Fusarium acuminatum* Ellis and Everhart emend. Wollenweber.
15. *Fusarium caudatum* Wollenweber.
16. *Fusarium longipes* Wollenweber and Reinking.
VII. Section *Roseum* Wollenweber.
17. *Fusarium anthophilum* (A. Braun) Wollenweber.
VIII. Section *Liseola* Wollenweber, Sherbakoff, Reinking, Johann, and Bailey.
18. *Fusarium moniliforme* Sheldon.
19. *Fusarium moniliforme* Sheldon var. *erumpens* Wollenweber and Reinking.
20. *Fusarium moniliforme* Sheldon var. *subglutinans* Wollenweber and Reinking.
21. *Fusarium moniliforme* Sheldon var. *maius* Wollenweber and Reinking.
22. *Fusarium neoceras* Wollenweber and Reinking.
IX. Section *Lateritium* Wollenweber.
23. *Fusarium fructigenum* Fries var. *maius* Wollenweber forma 1 Wollenweber and Reinking.
XI. Section *Spicarioides* (Wollenweber subsection) Wollenweber, Sherbakoff, Reinking, Johann, and Bailey.
24. *Fusarium decemcellulare* Brick.
XII. Section *Saubinetii* Wollenweber.
25. *Fusarium macroceras* Wollenweber and Reinking.
XIII. Section *Elegans* Wollenweber.
Subsection *Orthocera* Wollenweber.
26. *Fusarium bostrycoides* Wollenweber and Reinking.
27. *Fusarium orthoceras* Appel and Wollenweber.
28. *Fusarium orthoceras* Appel and Wollenweber var. *triseptatum* Wollenweber.

Subsection *Constrictum* Wollenweber.

29. *Fusarium bulbigenum* Cooke and Massee.
30. *Fusarium oxysporum* Schlechtendal.
31. *Fusarium oxysporum* Schlechtendal var. *nicotianae* Johnson.
32. *Fusarium cubense* Erwin F. Smith.
33. *Fusarium aurantiacum* (Link) Saccardo.
34. *Fusarium lutulatum* Sherbakoff.

XIV. Section *Martiella* Wollenweber (including *Pseudomartiella* Wollenweber.

35. *Fusarium solani* (Martius pro parte) Appel and Wollenweber var. *minus* Wollenweber.
36. *Fusarium solani* (Martius pro parte) Appel and Wollenweber var. *suffuscum* Sherbakoff.
37. *Fusarium solani* (Martius pro parte) Appel and Wollenweber.
38. *Fusarium alluviale* Wollenweber and Reinking.
39. *Fusarium martii* Appel and Wollenweber var. *minus* Sherbakoff.
40. *Fusarium martii* Appel and Wollenweber var. *viride* Sherbakoff.
41. *Fusarium martii* Appel and Wollenweber.
42. *Fusarium viride* (Lechm.) Wollenweber.
43. *Fusarium radicicola* Wollenweber.
44. *Fusarium striatum* Sherbakoff.
45. *Fusarium javanicum* Koorders.
46. *Fusarium theobromae* Appel and Strunk.
47. *Fusarium ensiforme* Wollenweber and Reinking.

Hypocreales:

Hypomyces (Fries).

48. *Hypomyces ipomoeae* (Halsted) Wollenweber.

DESCRIPTIONS OF GENERA, SECTIONS, SPECIES, VARIETIES, AND FORMS

Genus FUSARIUM Link

Fusarium LINK, Mag. Ges. Nat. Freunde 3 (1824) 10; SACCARDO, Syll. Fung. 4 (1886) 694; APPEL and WOLLENWEBER, Arb. aus. d. Kais. Biol. Anst. f. Land- u. Forstw. 8 (1910) 60–61; WOLLENWEBER, Phytopath. 3 (1913) 24–50; Ber. der Deut. Bot. Gesell. 31 (1913) 17–34; Journ. Agr. Research 2 (1914) 251–285; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 125; WOLLENWEBER, SHERBAKOFF, REINKING, JOHANN, and BAILEY, Journ. Agr. Research 30 (1925) 833–843.

Hyphomycetes and conidial stages of ascomycetes that have no black or pure gray color either in mycelium or in conidia; macroconidia acrogenous, typically septate, sickle-shaped, and not rounded at the ends; microconidia, chlamydospores, and sclerotia may be present.

I. Section EUPIONNOTES Wollenweber

Eupionnotes WOLLENWEBER, Phytopath. 3 (1913) 206 and 219; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 131; WOLLENWEBER, Ann. Myc. 15 (1917) 53; Ber. der Deut. Bot. Gesell. 35 (1918) 732.

Eupionnotes always present, spread out, dense, typical aërial mycelium absent, orange to salmon; conidia nearly cylindrical to sickle-shaped, moderately curved, slightly dorsiventral, apex ellipsoidal to conical, basis mostly apedicellate, septate, but septa frequently inconspicuous; chlamydospores 1-celled, 2-celled, in chains, rarely in heaps, or absent. Color type, orange to bright salmon.

Subsection CHLAMYDOSPORA Wollenweber

Chlamydospora WOLLENWEBER, Ann. Myc. 15 (1917) 53.

Differs from subsection *Aquaeductuum* by the presence of chlamydospores. Definite sporodochia sometimes tubercular, and sclerotia may occur.

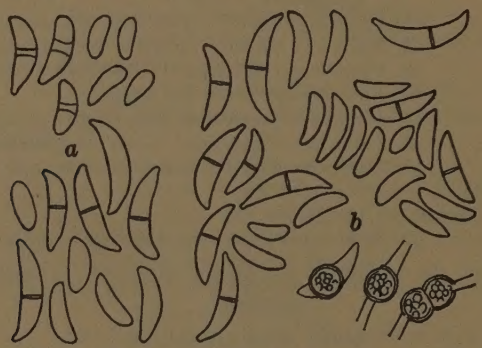

FIG. 1. *Fusarium pusillum* Wollenweber; *a*, conidia from pionnotes of 1-month-old hard potato-agar culture; *b*, *Fusarium dimerum* Penzig; conidia and chlamydospores of 2-month-old hard potato-agar culture.

FUSARIUM PUSILLUM Wollenweber. Text fig. 1, *a*.

Fusarium pusillum WOLLENWEBER, Fus. aut. del. Supplement No. 550 (1924).

Pionnotes yellow to golden, moderately spread out, in general similar to *F. dimerum;* conidia curved, 1-celled, 5 to 8 by 2.25 μ; rarely 1-septate; chlamydospores may be present.

Habitat.—On sun-burned Congo banana fruit (*Musa sapientium* Linnæus). Panama. Central America (*V. C. Dunlap 137, R 115*).

Fusarium pusillum differs primarily from *F. dimerum* in that the majority of the conidia are 1-celled. Both species are

easily distinguished from all other fusaria by their characteristic, minute, 1-septate conidia. The fungus was not isolated by Reinking, but was obtained from Dr. V. C Dunlap in Panama.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 1.5 months old have no typical aërial mycelium, but have a coarse radiating mycelium in the agar. A pionnotal film is produced over the slant and is pinkish buff in young and cinnamon buff in 2-month-old cultures.

Oat agar.—No true aërial mycelium is present, but a dense matted stroma is developed over the slant. It is pale pinkish buff in young and old cultures. Light pinkish cinnamon and cinnamon pionnotes are produced.

Rice.—None to a scant aërial mycelium is produced. Pionnotes are formed over rice. In young cultures they are ochraceous salmon, and in older cultures rufous and cartridge buff at the base. The rice in older cultures may be mustard yellow.

Potato-tuber plug.—Pionnotal masses, with coarse and tufted mycelial strands, are present here and there over the cylinders. In younger cultures the growth is light buff and cinnamon rufous, while in older cultures it may be cinnamon buff or cinnamon rufous and leathery.

Melilotus stems.—Pinkish cinnamon pionnotes are produced in 2-month-old cultures over stem. Stroma erumpent, and tufts of pale pinkish buff mycelium are present here and there over the stem.

Green bean pod.—On cultures 1 to 2 months old, cinnamon and mikado brown pionnotes are formed over the bean pod.

MEASUREMENTS OF CONIDIA

Hard potato agar; cultures 1 month old; conidia from pionnotes:
Conidia—
0-septate, 90 per cent, 7 to 12 by 2.5 to 3.25 μ.
1-septate, 10 per cent.

FUSARIUM DIMERUM Penzig. Plate 1, fig. 1; text fig. 1, *b*.

Fusarium dimerum PENZIG, Michelia 2 (1882) 484; SACCARDO, Syll. Fung. 4 (1886) 704; LINDAU, Rab. Krypt. Fl. Pilze 9 (1910) 566; APPEL and WOLLENWEBER, Arb. Kais. Biol. Anst. Land- u. Forstw. 8 (1910) 37, text fig. 2; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 127; WOLLENWEBER, Ann. Myc. 15 (1917) 9–10; Ber. der Deutsch Bot. Gesell. 35 (1918) 732.

Pionnotes pale cinnamon pink to orange pink, moderately spread out; tubercular sporodochia present, conidia curved,

approaching pedicellate, typically 1-septate, 13.5 by 2.75 (8 to 18 by 2 to 3.5) μ, often 0-septate, 12 by 2.75 (4.5 to 16 by 2 to 3.5) μ; stroma erumpent, chlamydospores 3.5 to 6 μ in diameter, in mycelium and conidia.

Habitat.—On cut surface of decaying banana pseudostem (*Musa sapientium* Linnæus) and in the soil (*R 154*). Tela, Honduras, Central America (*Reinking R 154*).

GROWTH ON VARIOUS MEDIA

Hard potato agar.—No true aërial mycelium is produced. A radiating film of mycelium may be formed under the pionnotal mass on the agar. In pionnotes it is pale cinnamon pink in young cultures and vinaceous cinnamon in older cultures up to 2 months old. Pionnotes masses are present over the slant. They are pale pinkish buff on young cultures and vinaceous cinnamon and buff pink on older cultures.

Oat agar.—A dense, matted, pale pinkish buff stroma is formed over slant. Pionnotes are present over the slant and are light pinkish cinnamon and cinnamon.

Rice.—A mycelial mass is produced in with the pionnotes. It is waxy yellow in young cultures, pale cinnamon pink and cinnamon buff and leathery in older cultures. Under certain conditions orange pink or rufous may be produced. The rice in older cultures may be amber yellow or yellow ocher. The pionnotes growth is pale cinnamon pink on young cultures, salmon color and light ochraceous salmon on older cultures.

Potato-tuber plug.—The mycelium in with the pionnotes is cartridge buff in young cultures and pinkish cinnamon in older. A stroma erumpent, which is warm buff when young and bister and pinkish buff when older, is usually developed here and there over the cylinder. The pionnotes mass is generally vinaceous pink.

Melilotus stem.—The mycelium in with the pionnotes is pinkish buff. The stem in older cultures is covered with a stroma erumpent; the individual bodies measure from 0.5 to 3 mm in diameter. Light pinkish cinnamon and pinkish cinnamon pionnotes are developed over the stem. In older cultures brick red to reddish brown perithecialike sclerotial stromata, resembling a *Nectria*, may develop; the latter bodies are still under observation.

Green bean pod.—The mycelium in with the pionnotes is scant and pale pinkish cinnamon to cinnamon and light pink-

ish cinnamon. A pionnotes mass is produced over the bean and in older cultures is vinaceous cinnamon or orange cinnamon. A stroma erumpent, with individual bodies measuring 0.5 to 1 mm in diameter, develops over the bean in older cultures. It is cinnamon and snuff brown.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 10 days old; conidia from pionnotes:
Conidia—
0-septate, 100 per cent, 12 by 2.75 (4.5 to 16 by 2.25 to 3.5) μ.
Hard potato agar; culture 2 months old; conidia from pionnotes:
Conidia—
0-septate, 55 per cent.
1-septate, 45 per cent, 8 to 18 by 2 to 3.5 μ.
Morus stem, thirty days:
0-septate, 19 per cent.
1-septate, 81 per cent, 10 to 18 by 2 to 2.5 μ.
Green bean pod; culture 10 days old; conidia from pionnotes:
Conidia—
0-septate, 58 per cent, 9.5 by 3 (6.25 to 12 by 2.75 to 3.25) μ.
1-septate, 42 per cent, 13.5 by 3.25 (11 to 17 by 3 to 3.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
0-septate, 71 per cent, 12 by 2.75 μ.
1-septate, 29 per cent, 13.5 by 3 μ.

III. Section SPOROTRICHIELLA Wollenweber

Sporotrichiella LEWIS, Maine Agr. Exp. Sta. Bull. 219 (1913) 256; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 183; WOLLENWEBER and REINKING, Phytopath. 15 (1925) 156.

Conidia for the most part scattered in the aërial mycelium, pyriform to globose, unicellular, sporodochia absent in typical species, macroconidia few, fusiform or sickle-shaped, septate; chlamydospores and sclerotia may be present. Color type, rose color. Species, *F. poae* (Peck) Wollenweber; *F. sporotrichioides* Sherbakoff; *F. chlamydosporum* Wollenweber and Reinking.

FUSARIUM CHLAMYDOSPORUM Wollenweber and Reinking. Plate 1, fig. 2; text fig. 2.

Fusarium chlamydosporum WOLLENWEBER and REINKING, Phytopath. 15 (1925) 156.

Microconidia borne on irregularly branched conidiophores, ovoid, pyriform, mostly unicellular, 6 to 9 by 2.5 to 4 μ, rarely 1–septate, 11 to 16 by 3 to 3.5 μ; macroconidia scattered, rare, sickle-shaped, 1- to 3-septate; 3-septate, 27 to 32 by 3.5 to 4 μ; sporodochia absent; mycelium floccose, from rose to carmine, from sulphuric to dark brown; plectenchymic stroma sometimes

tubercular; chlamydospores globose to pear-shaped, rugose to spiny, ocherous, terminal or intercalary, 1- to 2-celled, in chains or clusters, 10 to 16 μ in diameter.

Fusarium chlamydosporum produces mostly microconidia of the *sporotrichum* type, a few sickle-shaped macroconidia, and an abundance of large chlamydospores that are characteristic for the species. The aërial mycelium develops swellings in some hyphæ that differ from chlamydospores in having no double wall (Plate 1, fig. 2). Such swellings are formed in *F. flocciferum* of the section *Discolor*, and in species of the section *Gibbosum*.

Habitat.—On the exterior of the pseudostem (*R 38*) and interior of a cut pseudostem of banana (*Musa sapientium* Linnæus) and in the air and soil. Tela, Honduras, Central America (*Reinking R 38*).

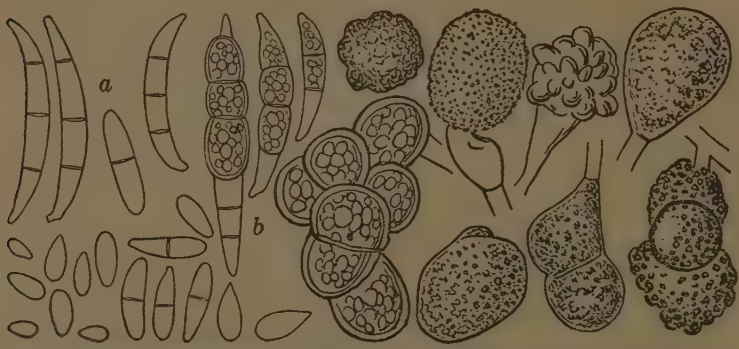

FIG. 2. *Fusarium chlamydosporum* Wollenweber and Reinking; *a*, conidia from mycelium of 2-month-old hard potato-agar culture; *b*, chlamydospores in conidia and mycelium of 2-month-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Young cultures 12 days old have a thick, dense, matted mass of mycelium that is cameo pink, thulite pink, spinel red, rosolane purple with spots of pinkish cinnamon on top and tawny olive and Saccardo's umber lower down. Older cultures, up to 2 months old, may be cameo pink, spinel red or cartridge buff, cinnamon buff, and cinnamon brown or buckthorn brown in places at base. The mycelium is dense and matted. The agar may be turned spinel red and Indian lake or Dresden brown. Bone brown thick stromatic masses may be produced at the base. On plate cultures the mycelial growth after one month is white and pale pinkish cinnamon over plate and

powdery in the center. The mycelium in the substratum is spinel red.

Potato-agar plate, 5 per cent dextrose.—The aërial mycelium is thick, dense, matted, and felty. It is cameo pink, spinel pink, spinel red to ferruginous in places. In the substratum it is brick red or Vandyke red.

Oat agar.—On oat agar 1 month old a thick, dense, matted, felty mass of mycelium is produced over slant. The main part is white and seashell pink with a little yellow ocher and buckthorn brown. The edges of the growth may be spinel red. The growth is powdery in places. Few mummy brown stromatic masses of mycelium may develop in spots.

Rice.—In young cultures, 2 to 3 weeks old, the mycelium is thick, matted, and felty and is white and rose pink above and yellow ocher around the rice below. The rice is colored dark vinaceous brown and seal brown. Cultures 2 months old have a leathery growth of mycelium that is cartridge buff or light ochraceous salmon on top with yellow ocher, Dresden brown, and mummy brown in places below. Jade green may appear in some cultures. Seal brown stromatic masses of mycelium may be produced in places.

Potato-tuber plug.—Three-week-old cultures have a dense, matted, white mycelium on top with pomegranate purple on the sides, especially where it touches the glass. Older cultures, up to 2.5 months old, are the same with an addition of Dresden brown and mummy brown in places. Dense stromatic masses that are mummy brown, often with pomegranate purple, may develop.

Melilotus stem.—In 1-month-old cultures a thick matted mass of mycelium is developed over the stem. It is pale pinkish buff, cinnamon buff, and clay color and powdery in places.

Alnus stem.—A dense mass of mycelium is developed on the top of the stem in cultures 1 month old. Scanty mycelium is produced on the side of the twig. The mycelium is spinel red and Indian lake.

Green bean pods.—In 3-week-old cultures the mycelial growth is dense and matted, white, cameo pink, thulite pink, and light rosolane purple. Older cultures have a dense mycelium that is cartridge buff, and pale pinkish cinnamon to cinnamon. Pinks and purples, as in the young cultures, may also be present.

Banana peel.—A dense matted mycelium that is white, cameo pink, thulite pink, and light rosolane purple is produced in 3-week-old cultures.

MEASUREMENTS OF CONIDIA

Hard potato agar; culture 2 months old; conidia from mycelium:
Conidia—
0-septate, 98 per cent, 7 by 3.25 (6 to 9 by 2.5 to 4) μ.
3-septate, 2 per cent, 29 by 4 (27 to 32 by 3.5 to 4.5) μ.

V. Section ARTHROSPORIELLA Sherbakoff

Arthrosporiella SHERBAKOFF, N. Y (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 161; WOLLENWEBER, Ber. der Deut. Bot. Gesell. 35 (1918) 733; WOLLENWEBER and REINKING, Phytopath. 15 (1925) 157.

Aërial mycelium abundant, whitish to flesh color; sporodochia and pionnotes typically absent; pionnotes present in few species; microconidia in aërial mycelium, spindle-shaped or lanceolate, apedicellate, 0- to 3-septate; macroconidia in masses. Isabella color or ochraceous, sickle-shaped, attenuate, often pedicellate, 3- to more-septate; chlamydospores typically intercalary, sclerotia rare, stroma ochraceous to chestnut brown or rosy, spread out, sometimes sclerotially erumpent.

FUSARIUM SEMITECTUM Berkeley and Ravenel. Plate 1, fig. 3; text fig. 3.

Fusarium semitectum BERKELEY and RAVENEL, Grevillea 3 (1875) 98; SACCARDO, Syll. Fung. 4 (1886) 718; WOLLENWEBER, Ann. Myc. 15 (1917) 11; WOLLENWEBER and REINKING, Phytopath. 15 (1925) 157.

Aërial mycelium white to flesh color or Isabella color, stroma plectenchymic, dark ochraceous, sometimes violet carmine,[2] chlamydospores intercalary in mycelium and conidia, spiny at maturity; sporodochia absent; conidia scattered in aërial mycelium, spindle-shaped, lanceolate, slightly curved, apedicellate, appendicular, when smaller 0- to 2-septate, when larger 3- to 5- (6- or 7-) septate; 0-septate, 12 by 3 to 3.5 μ; 1-septate, 11 to 21 by 2.5 to 4.5 μ; 2-septate, 16 to 24 by 3.25 to 5 μ; 3-septate, 18 to 40 by 3 to 5.5 μ; 4-septate, 29 to 45 by 4 to 5.5 μ; 5-septate, 36 to 52 by 4 to 5.5 μ; 6- to 7-septate, 37 to 57 by 4.5 to 5.5 μ.

Habitat.—On dead floral parts at the end of banana fruit (*R 50*), on anther and pollen grains of banana, on dead floral parts of banana on the ground, in the interior of a cut pseudostem of banana, and on diseased banana fruit (*Musa sapientium* Linnæus), at blossom end rot of tomato fruit (*Lycopersicum esculentum* Miller), and in the air as air-borne spores. Tela, Honduras, Central America (*Reinking R 50*).

[2] Other strains of doubtless the same species, isolated from bananas of the European market by Wollenweber, as a rule do not produce a violet carmine color of the stroma.

Fusarium semitectum is generally widespread throughout banana plantations, growing on the dead floral remains at the end of the individual banana fruits and decaying banana fruit and floral parts on the ground. Its pathogenicity has not been established.

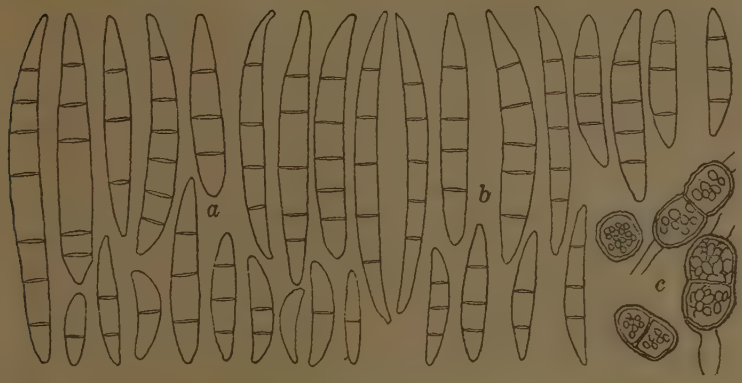

FIG. 3. *Fusarium semitectum* Berkeley and Ravenel; *a*, conidia from mycelium of 8-day-old rice culture; *b*, conidia from mycelium of 1-month-old hard potato-agar culture; *c*, chlamydospores from 14-day-old water culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—On young cultures a median dense, matted and, in places, tufted mycelium develops over slant. It is cartridge buff, pale pinkish buff, and pale pinkish cinnamon with cinnamon buff at the base. A buckthorn brown ring may be produced at the base. On the agar, under the main mass of mycelium, the growth is salmon buff or cinnamon buff. The agar may be dark vinaceous brown at the base of the slant. Older cultures up to 3 months of age have a dense matted mycelium that is light buff, buckthorn brown, or snuff brown. On potato-agar plates 2 months old a thin white mycelial growth, which may be distinctly zonate, is produced.

Potato-agar plate, 5 per cent dextrose.—On cultures 1 month old a scant aërial mycelium is produced, and the mycelium in the substratum is sayal brown and zonate.

Rice.—In cultures 3 weeks old the mycelium is matted and felty, but not extremely thick. It is warm buff and light pinkish cinnamon above, chestnut brown and carob brown on the sides, and buckthorn brown and mummy brown below. The rice turns Vandyke red and Indian lake in places. In older cultures,

up to 2 months of age, the mycelium is leathery and Natal brown on the glass above with bone brown on rice and wood brown or Natal brown lower down. A salmon buff coloration may be present at the base.

Potato-tuber plug.—On cultures 3 weeks old the mycelium is dense, matted, and felty with a light buff, pale ochraceous buff, honey yellow, or Isabella color. Clay color may be produced where the mycelium touches the glass. Cultures 2 to 3 months old are dense, felty, matted, and leathery in places. The mycelium is cartridge buff, pinkish buff, cinnamon brown, or buckthorn brown and Dresden brown in places.

Melilotus stem.—On cultures 2 months old a pale pinkish buff, matted, felty mycelium is produced over the stem.

Green bean pod.—In young cultures 3 weeks old, the mycelium is dense, matted, and felty over the bean with a color that is pale pinkish cinnamon, pale pinkish buff, pinkish buff, and sometimes with cinnamon buff in places. Under the mass of mycelium on the bean the growth may be cinnamon or sayal brown. Older cultures have a thin, matted mycelium that is pinkish buff, cinnamon buff, and clay color with sayal brown in places.

Banana peel.—A scant to median thin, pale pinkish buff, and pinkish buff or cinnamon buff mycelium is produced over the banana peel.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; cultures 1 month old; conidia from mycelium:
Conidia—
0-septate, 51 per cent, 8.5 by 2.75 (4 to 16 by 2.25 to 3.25) μ.
1-septate, 4 per cent, 15.5 by 3.5 (10 to 19 by 2.75 to 4) μ.
2-septate, 4 per cent, 20 by 4 (15 to 25 by 3.25 to 4.5) μ.
3-septate, 33 per cent, 30 by 4 (15 to 45 by 3.25 to 5) μ.
4-septate, 6 per cent, 40 by 4 (27 to 47 by 3.5 to 5) μ.
5-septate, 1 per cent, 35 by 4.5 (23 to 46 by 4.5 to 5.5) μ.
6-septate, 1 per cent, 33 by 4.5 μ.

Green bean pod; cultures 10 days old; conidia from mycelium:
Conidia—
0-septate, 1 per cent, 9.5 by 3.5 (4 to 13 by 2.25 to 3.5) μ.
1-septate, 10 per cent, 14 by 4 (12 to 19 by 3 to 4.5) μ.
2-septate, 5 per cent, 20 by 3.75 (13 to 24 by 3 to 5.5) μ.
3-septate, 42 per cent, 26 by 4.25 (18 to 40 by 3.5 to 6.25) μ.
4-septate, 22 per cent, 38 by 4.75 (25 to 45 by 3.5 to 6.25) μ.
5-septate, 12 per cent, 37 by 4.75 (26 to 50 by 4 to 6.25) μ.
6-septate, 7 per cent, 38 by 5.5 (30 to 53 by 4.5 to 6.25) μ.
7-septate, 1 per cent, 42 by 5 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

0-septate, 25 per cent, 9 by 3.25 (4 to 16 by 2.25 to 3.5) μ.
1-septate, 7 per cent, 15 by 3.75 (10 to 19 by 2.75 to 4.5) μ.
2-septate, 5 per cent, 20 by 3.75 (13 to 25 by 3 to 5.5) μ.
3-septate, 38 per cent, 28 by 4 (15 to 45 by 3.25 to 6.25) μ.
4-septate, 14 per cent, 39 by 4.5 (25 to 47 by 3.5 to 6.25) μ.
5-septate, 6 per cent, 42 by 4.5 (23 to 50 by 4 to 6.25) μ.
6-septate, 4 per cent, 36 by 5 (30 to 53 by 4.5 to 6.25) μ.
7-septate, 1 per cent, 42 by 5 μ.

FUSARIUM CAMPTOCERAS Wollenweber and Reinking. Plate 1, fig. 4; text fig. 4.

Fusarium camptoceras WOLLENWEBER and REINKING, Phytopath. 15 (1925) 158.

Aërial mycelium white to flesh to blood red or Isabella color; stroma dark ochraceous, sometimes flesh color; chlamydospores intercalary in mycelium and conidia; sporodochia absent; co-

FIG. 4. *Fusarium camptoceras* Wollenweber and Reinking; *a*, conidia, long narrow type, from mycelium of 8-day-old hard potato-agar culture; *b*, conidia, short broad type, from mycelium of 15-day-old hard potato-agar culture; *c*, chlamydospores from 15-day-old water culture; *d*, conidiophore from 12-day-old hard potato-agar culture.

nidia scattered in the aërial mycelium; sickle-shaped, slightly pointed at ends, more or less constricted at top end, rounded or conical at base, sometimes apedicellate, however, appendicular, smaller conidia 0- to 2-septate, larger conidia 3- to 5-(6- or 7-) septate; 0-septate, 7 to 12 by 2.5 to 3.5 μ; 1-septate, 11 to 18 by 3 to 4 μ; 2-septate, 14 to 26 by 3.5 to 5 μ; 3-septate, 17 to 32 by 3.5 to 5.5 μ; 4-septate, 22 to 40 by 3.5 to 6 μ; 5-septate, 29 to 52 by 4.5 to 6 μ; 6-septate, 25 to 58 by 4.5 to 5.5 μ; 7-septate, 31 to 51 by 4 to 5.5 μ.

Habitat.—On rotted fruit of banana (*Musa sapientium* Linnæus) and cacao (*Theobroma cacao* Linnæus) (*R 78*) and in the soil. Tela, Honduras, Central America (*Reinking R 78*).

Differs from *F. semitectum* by somewhat higher septation and more-curved conidia, and by the production of ox-blood red in the stroma.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—On 2-week-old agar, a medium thick, matted mycelium, sometimes in concentric rings, of thick and thin mycelium is formed over the slant. The mycelium is at first cartridge buff and chamois and later turns light buff and pinkish buff with a sayal brown ring at the base. Older cultures have a matted, felty, thick growth of light buff, pinkish buff, and buckthorn brown mycelium. Under the mycelial mass on the agar the growth may be cinnamon. On potato-agar plates 2 months old a pale pinkish cinnamon, scant, and zonate mycelium is present over the plate.

Potato-agar plate, 5 per cent dextrose.—The aërial mycelium on plates 1 month old is zonate and radiate, short woolly to felty, and pale pinkish buff and cinnamon buff. The mycelium in the substratum is auburn.

Oat agar.—Oat-agar cultures 1 month old have a thick felty mycelium over the slant. The mycelium is pale pinkish cinnamon and tawny olive in patches below. The agar is turned sayal brown.

Rice.—Young cultures 3 weeks old have a dense, felty, matted mycelium that is light buff and buckthorn brown above, and mummy brown, Natal brown, or bone black below. The rice may be changed to garnet red. Older cultures may be somewhat leathery and are cartridge buff and cinnamon on top, bone brown on sides, and pinkish buff and light pinkish cinnamon and sometimes orange vinaceous below. The rice is often ox-blood red and garnet brown.

Potato-tuber plug.—Young cultures 3 weeks old have a dense, felty mass of mycelium over the potato. The mycelium is mainly light buff with clay color, tawny olive, and black where it touches the glass. Older cultures are felty and matted, chiefly light buff with buckthorn brown, cinnamon brown, Dresden brown, mummy brown, and blackish brown(3) in places. The mycelium may be leathery below.

Melilotus stem.—Cultures 1 month old have a pale pinkish cinnamon, medium dense, and felty mycelial growth over the stem.

Alnus stem.—A scant, pale pinkish cinnamon growth of mycelium is produced over the stem after one month's growth.

Green bean pod.—On cultures 10 days old a white and pinkish buff, felty, matted mycelium is produced. Older cultures are cartridge buff, cream buff with pale pinkish buff, and pinkish cinnamon in places.

Banana peel.—A medium dense, matted, pale pinkish buff mycelium is produced over the banana peel on 2-month-old cultures.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; cultures 1 month old; conidia from mycelium:
Conidia—
0-septate, 4 per cent, 10 by 3.25 (7 to 12 by 2.25 to 3.5) μ.
1-septate, 7 per cent, 14 by 3.5 (13 to 15 by 3.5 to 4) μ.
2-septate, 5 per cent, 19 by 4 (14 to 19 by 3.5 to 4.5) μ.
3-septate, 20 per cent, 22 by 4 (17 to 24 by 3.5 to 4.5) μ.
4-septate, 9 per cent, 27 by 4.5 (22 to 28 by 4.5 to 5.25) μ.
5-septate, 18 per cent, 37 by 5.25 (32 to 37 by 5 to 6) μ.
6-septate, 33 per cent, 34 by 4.5 (25 to 41 by 4.5) μ.
7-septate, 4 per cent, 46 by 4.75 (46 by 4.5 to 5) μ.
8-septate, rare, 65 by 5 μ.

Green bean pod; cultures 1 month old; conidia from mycelium:
Conidia—
0-septate, rare, 8 by 2.75 μ.
1-septate, 1 per cent, 11 by 3.5 μ.
2-septate, 8 per cent, 17 by 4 μ.
3-septate, 40 per cent, 23 by 4.75 (18 to 28 by 3.5 to 5.5) μ.
4-septate, 32 per cent, 31 by 4.5 (26 to 35 by 3.5 to 5.5) μ.
5-septate, 13 per cent, 32 by 5 (32 to 33 by 4.5 to 5.5) μ.
6-septate, 3 per cent, 33 by 5 (31 to 37 by 4.5 to 5.5) μ.
7-septate, 3 per cent, 40 by 4.25 (36 to 44 by 4 to 4.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 30 per cent, 23 by 4.25 (17 to 28 by 3.5 to 5.5) μ.
4-septate, 21 per cent, 29 by 4.5 (22 to 35 by 3.5 to 5.5) μ.
5-septate, 15 per cent, 35 by 5 (32 to 37 by 4.5 to 6) μ.
6-septate, 18 per cent, 34 by 4.75 (25 to 41 by 4.5 to 5.5) μ.
7-septate, 3 per cent, 43 by 4.5 (36 to 46 by 4 to 5) μ.

FUSARIUM INCARNATUM (Robinson) Saccardo. Text fig. 5.

Fusarium incarnatum SACCARDO, Michelia 2 (1881) 296; Syll. Fung. 4 (1886) 712; WOLLENWEBER, Ann. Myc. 15 (1917) 11; Journ. Agr. Research 2 (1914) 258.

Mycelium floccose lanate, brownish white to salmon color; sporodochia and pionnotes absent; conidia formed into a salmon-color powder, subnormal conidia unicellular or septate, rounded at the ends, seldom pointed, normal conidia show characters of

the section *Discolor*, but are less curved and have mostly a conical, seldom a pedicellate base; slender conidia, occasionally found, should not be confused with the section *Elegans* (*F. orthoceras*); 3-septate conidia, 20 to 25 by 3.5 to 4.5 μ; 5-septate, 30 to 50 by 3.75 to 5 μ, may be predominant; 10-septate conidia occur more rarely; conidiophore mostly irregularly branched, sometimes with slightly verticillate ramifications; chlamydospores 1- to 2-celled, formed, intercalated from hyphæ and from conidia; olive brown plectenchymata of remarkable longevity produced.

FIG. 5. *Fusarium incarnatum* (Robinson) Saccardo; *a*, conidia from mycelium of 1-month-old oatmeal-agar culture; *b*, conidia from mycelium of 1-month-old hard potato-agar culture; *c*, chlamydospores from 1-month-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

The fungus resembles *Fusarium trichothecioidea* Wollenweber in general appearance. *Fusarium semitectum* is closely related, but may have smaller conidia and on the average fewer septa.

Habitat.—On petiole of decaying undetermined leaf on ground (*R 89*) and in the soil. Trujillo, Honduras, Central America (*Reinking R 89*).

Hard potato agar.—Young cultures 4 days old have a medium dense, cottony, and somewhat matted, white growth. As the cultures grow older the mycelium becomes denser and turns mainly pale pinkish buff with possibly tawny olive below. When fruiting a more or less powdery, salmon buff growth is produced. Older cultures, up to 3 months old, are cartridge buff above and pinkish cinnamon, dense, and matted below. A buckthorn brown ring may be produced at the base. Concentric

rings of a dense and thin mycelium may also be formed. On potato-agar plates 2 months old a pale pinkish buff, thin, felty mass of mycelium is developed.

Oat agar.—A pale pinkish cinnamon, thick, dense, felty mass of mycelium that is tawny olive at the base and sides of the slant is present in cultures 1 month old.

Rice.—On cultures 20 days old the mycelium on top is white, light buff, and pale cinnamon pink, lower down it is buckthorn brown and zinc orange on the glass. On the sides of the rice it may also be flesh color or cameo pink. The rice itself turns shrimp pink and often mustard yellow on top. Cultures 2 months old have a light ochraceous buff and ochraceous salmon, leathery mycelium on top, warm buff and light buff mycelium at sides, and ochraceous orange or pale grayish vinaceous in the rice below. Clove brown or Dresden brown patches may appear in places. Powdery spore masses are ochraceous salmon.

Potato-tuber plug.—Cultures 1 month old have a white, pinkish buff and tawny olive, dense, matted, felty mycelium over the potato. Older cultures are the same with a change to cinnamon and sayal brown in places.

Melilotus stem.—Cultures 1 month old have a pale pinkish buff, medium dense, and matted mycelium over the stem.

Alnus stem.—Same as on *Melilotus* stem.

Green bean pod.—Cultures 1 to 2 months old have a pale pinkish buff, pinkish buff, or a pale pinkish cinnamon, light pinkish cinnamon to cinnamon, dense, thick, matted, and felty mycelium over bean. Plectenchymic masses that are warm buff may be produced in places.

Banana peel.—Cultures 26 days old have a scant white and orange cinnamon mycelial growth.

Mature corn stalk.—A scant, white mycelial growth is produced in young and old cultures.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 1 month old; conidia from mycelium:
Conidia—
0-septate, 2 per cent, 12 by 3 (10 to 14 by 2.75 to 3.25) μ.
1-septate, 14 per cent, 21 by 3 (18 to 27 by 2.75 to 3.5) μ.
2-septate, 5 per cent, 25 by 3.25 μ.
3-septate, 55 per cent, 27 by 3.5 (21 to 32 by 3.25 to 4) μ.
4-septate, 7 per cent, 34 by 4.25 (32 to 36 by 4 to 4.5) μ.
5-septate, 17 per cent, 39 by 4.5 (33 to 42 by 4.5) μ.
6-septate, rare, 39 by 4 μ.
Not in best high cultures.

Oat agar; cultures 1 month old; conidia from mycelium:
Conidia—
3-septate, 30 per cent.
4-septate, 28 per cent.
5-septate, 42 per cent.

Green bean pod; culture 12 days old; conidia from mycelium:
Conidia—
0-septate, 1 per cent, 8 by 2.25 μ.
1-septate, 5 per cent, 14 by 2.5 (9 to 17 by 2 to 2.75) μ.
2-septate, 2 per cent, 18 by 3 (18 to 19 by 2.75 to 3.25) μ.
3-septate, 25 per cent, 19 by 3.5 (17 to 23 by 3 to 4) μ.
4-septate, 10 per cent, 34 by 4 (30 to 41 by 3.5 to 4.5) μ.
5-septate, 41 per cent, 40 by 4.25 (35 to 44 by 4 to 5) μ.
6-septate, 8 per cent, 42 by 4.5 (37 to 48 by 4 to 5) μ.
7-septate, 2 per cent, 48 by 4.5 μ.
8-septate, 3 per cent, 56 by 5.25 (55 to 59 by 5 to 5.5) μ.
9-septate, 3 per cent, 61 by 4.5 (56 to 67 by 4.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 37 per cent, 23 by 3.5 (17 to 32 by 3 to 4) μ.
4-septate, 15 per cent, 34 by 4 (21 to 41 by 3.5 to 4.5) μ.
5-septate, 37 per cent, 39 by 4.25 (33 to 44 by 4 to 5) μ.

FUSARIUM DIVERSISPORUM Sherbakoff. Text fig. 6.

Fusarium diversisporum SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 161; WOLLENWEBER, Ann. Myc. 15 (1917) 11.

Sherbakoff's diagnosis, with slight changes, is as follows:

Aërial mycelium typically well developed, medium fine, white; typical sporodochia absent, pionnotes on mycelial sheet; conidia formed in a light pink cinnamon, powdery mass; conidia short, spindle-shaped (average 3-septate, 28 by 4.3 μ) to sickle-shaped, 5-septate, 48.5 by 3.63 (41 to 61 by 2.9 to 4.4) μ, 6- to 9-septate conidia common, 60 to 100 by 4.7 to 5.2 μ, slightly curved to straight and anguiform, apically pointed, sometimes distinctly but not prominently pedicellate; chlamydospores may be present, intercalary in mycelium and in conidia. *Fusarium diversisporum* produces a pionnotes and represents a border-line species to the section *Roseum*.

Habitat.—On tassel of corn and on brown spots in living leaves of corn (*Zea mays* Linnæus) (*R 75*). Tela, Honduras, Central America (*Reinking R 75*). Wollenweber has found also ocherous globose sclerotia in a strain of *F. diversisporum*, isolated from *Carica papaya* from the Philippines.[4]

[4] Cf. Fus. Aut. del. 118.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—On cultures 11 days old is developed a dense mycelial mass that is mainly pale pinkish buff with salmon and salmon buff where masses of conidia are produced, and tawny olive at the base. In older cultures the mycelium becomes flattened and changes from pale pinkish buff or light pinkish cinnamon with buckthorn brown at the base of the slant to cream buff and pinkish buff. On potato-agar plates 2 months old there is a scant aërial mycelium which is pale pinkish buff.

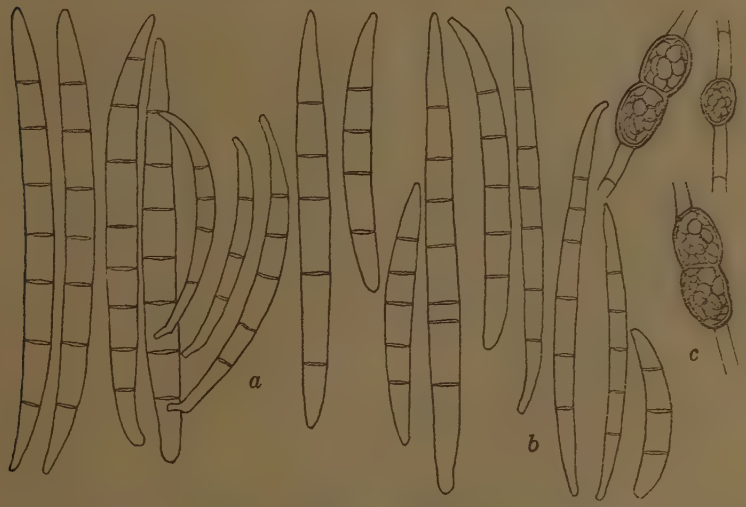

FIG. 6. *Fusarium diversisporum* Sherbakoff; *a*, conidia, large, slightly curved to spindle-shaped, nonpedicellate and small, spindle-shaped, pedicellate, from mycelium of 10-day-old hard potato-agar cuture; *b*, conidia, slightly curved to straight and anguiform, from pionnotes of 10-day-old oatmeal-agar culture; *c*, chlamydospores from 14-day-old water culture.

Potato-agar plate, 5 per cent dextrose.—A pale pinkish buff, scant aërial mycelium is produced on cultures 1 month old. The substratum is changed to light pinkish cinnamon.

Oat agar.—Cultures 1 month old have a medium thick and matted mycelium that is pale pinkish buff, usually with a mummy brown ring at the base and sides of the slant.

Rice.—Cultures 20 days old have a white, pale pinkish buff, buckthorn brown, and cinnamon brown, medium dense, and matted mass of mycelium over the rice. The mycelium may be leathery below. Older cultures, up to 2 months old, have a cartridge buff, pinkish buff, light pinkish cinnamon and cin-

namon brown, leathery mass over the rice. Where spores are produced in abundance in pionnotes, the culture is light ochraceous salmon.

Potato-tuber plug.—Cultures 1 month old have a dense matted growth of mycelium that is cream buff and cinnamon buff above and olive ocher and mummy brown below. Cultures 2 months old have a dense, matted, cinnamon brown mycelium above and buckthorn brown and mummy brown, leathery below. Pinkish buff and salmon buff, more or less powdery spore masses develop in places on the mycelium. Mummy brown plectenchymic bodies may also be formed.

Melilotus stem.—Cultures 1 month old have a pale pinkish buff, medium thin, and matted aërial mycelium over the stem.

Alnus stem.—Cultures 1 month old have a pale pinkish buff and pinkish buff, powdery, medium, scant mycelium in places on the stem.

Green bean pod.—Young and old cultures have a pale pinkish buff, pinkish buff, and cinnamon buff, dense, felty, and matted mycelium.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; cultures 22 days old; conidia from powdery masses in mycelium:

Conidia—

0-septate, rare.
1-septate, 1 per cent, 17 by 3 (14 to 21 by 2.25 to 3.5) μ.
2-septate, 1 per cent, 17 by 2.5 (15 to 18 by 2.25) μ.
3-septate, 25 per cent, 29 by 3.25 (19 to 36 by 2.75 to 4) μ.
4-septate, 20 per cent, 34 by 3.75 (29 to 44 by 3.25 to 4) μ.
5-septate, 50 per cent, 41 by 4.25 (32 to 61 by 3.5 to 4.45) μ.
6-septate, 2 per cent, 41 by 5 (40 to 64 by 5 to 5.5) μ.
7-septate, 1 per cent, 60 by 5 (56 to 72 by 4.5 to 5.5) μ.
8-septate, rare, 65 by 5 μ.

Oat agar; culture 2 weeks old; conidia from pionnotes:

Conidia—

3-septate, 6 per cent.
4-septate, 3 per cent.
5-septate, 82 per cent, 55 by 3 (44 to 66 by 2.75 to 3) μ.
6-septate, 9 per cent.

Rice; culture 2 months old; conidia from pionnotes:

Conidia—

1-septate, 6 per cent.
2-septate, 1 per cent.
3-septate, 14 per cent.
4-septate, 4 per cent.
5-septate, 61 per cent.
6-septate, 9 per cent.
7-septate, 5 per cent.

Green bean pod; culture 21 days old; conidia from mycelium:
Conidia—
0-septate, 2 per cent, 11 by 3.25 (7 to 15 by 2.25 to 3.5) μ.
1-septate, 6 per cent, 17 by 3 (14 to 23 by 2.25 to 3.25) μ.
2-septate, 4 per cent, 20 by 3.25 (15 to 26 by 2.75 to 3.5) μ.
3-septate, 45 per cent, 28 by 3.75 (16 to 41 by 3.25 to 4.5) μ.
4-septate, 14 per cent, 34 by 4 (24 to 47 by 3.5 to 5) μ.
5-septate, 28 per cent, 40 by 4 (32 to 50 by 3.5 to 5.5) μ.
6-septate, 1 per cent, 59 by 6 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 23 per cent, 29 by 3.5 (16 to 41 by 2.75 to 4.5) μ.
4-septate, 10 per cent, 34 by 3.75 (24 to 47 by 3.25 to 5) μ.
5-septate, 55 per cent, 45 by 3.75 (32 to 66 by 2.75 to 5) μ

FUSARIUM ANGUIOIDES Sherbakoff. Text fig. 7.

Fusarium anguioides SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 169.

Sherbakoff's description of the species is as follows:

Conidia of diverse types, ranging from arthrosporial (short, spindle-shaped with more or less rounded ends, 0- to 3-septate) to typically slightly curved or nearly straight and anguiform, 1- to 15-septate, 1- and 3-septate conidia typical for the first form

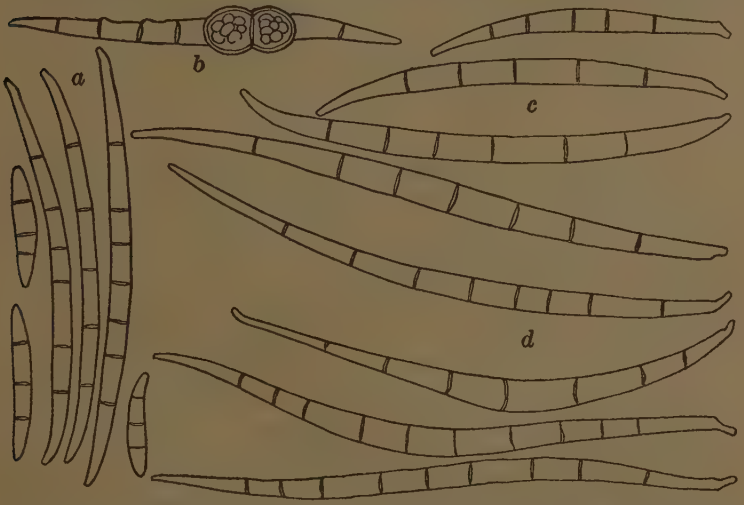

FIG. 7. *Fusarium anguioides* Sherbakoff; *a*, conidia, small, narrow, slightly curved, from mycelium of 1-month-old potato-tuber plug culture; *b*, chlamydospores in conidium from 1-month-old rice culture; *c*, conidia, large and broad, nearly straight, from pionnotes of 18-day-old oatmeal agar culture; *d*, conidia, large and broad, irregular, from pionnotes of 1-month-old rice culture.

and measuring 27 by 4.4 (20 to 38 by 3.9 to 5.3) μ; for the other form the conidia commonly measuring as follows:

5-septate, 51 by 4.2 (47 to 68 by 3.9 to 4.6) μ.
6- and 7-septate, 76 by 4.6 (65 to 86 by 4.2 to 5.2) μ.
8- and 9-septate, 89 by 4.86 (80 to 102 by 4.3 to 5.8) μ.

Color of conidia in pseudopionnotal layer on glucose potato agar, ranging from light pinkish cinnamon to cinnamon; arthrosporial conidia of common occurrence on aërial mycelium, but often the latter, especially on different agar, nearly absent, when a thin spore layer (pseudopionnotes) is produced for which anguiform conidia are typical.

We observed in addition intercalary chlamydospores in mycelium and conidia; no sporodochia were observed, but pionnotes developed. The term pseudopionnotes is not used in the present paper, as it is included in that of pionnotes. The main part of the spores developed from the mycelium. *Fusarium anguioides* represents a border-line strain to the section *Roseum* and resembles in some characters *F. anthophilum* (A. Braun) Wollenweber, from which it differs in higher septation of conidia and by the presence of chlamydospores.

Habitat.—On dead leaf petiole of undetermined plant on ground. Trujillo, Honduras, Central America (*Reinking 90*). On dried pods of pigeon pea (*Cajanus indicus* Spreng) and in soil. Tela, Honduras, Central America (*Reinking*). On plant débris. Jamaica (*C. G. Hansford 17, R 236*).

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 10 days old usually have a dense, matted mycelium that is chiefly pale pinkish buff and tawny olive at the base. Salmon and salmon buff spore masses, pionnotes, are developed over the agar. Cultures from 1 to 3 months old have a dense, matted, felty mycelium that is cartridge buff, light buff, pinkish buff, and cinnamon buff with buckthorn brown at the base of the slant.

Potato-agar plate, 5 per cent dextrose.—One-month-old plates have a scant aërial mycelium that is pale pinkish buff. The substratum is colored russet. A pionnotes is produced.

Oat agar.—One-month-old cultures have a scant aërial, powdery mycelium that is pale cinnamon pink and light vinaceous cinnamon. A stromatic mass of mycelium is produced over the slant with a pionnotes developed thereon.

Rice.—Twenty-day-old cultures have a white, pale pinkish buff and pale pinkish cinnamon, medium dense, matted my-

celium with spots of ochraceous tawny, Dresden brown, and mummy brown over rice. The mycelium may be leathery in places. Older cultures, up to 2 months of age, have a dense, matted mycelium that is cartridge buff, pinkish buff, and light pinkish cinnamon with sayal brown, tawny olive, and snuff brown in places. A pinkish buff pionnotes may be present.

Potato-tuber plug.—Eighteen-day-old cultures have a chamois and salmon buff, dense, matted mycelium. A salmon buff pionnotes may be present. Older cultures, between 1 and 2 months old, are felty and light buff on top with cinnamon brown, vinaceous brown, and Natal brown below. The mycelial mass may be leathery below. A vinaceous buff pionnotes may be produced.

Melilotus stem.—Scant pale cinnamon pink aërial mycelium is produced in 1-month-old cultures.

Alnus stem.—Scant, pale cinnamon pink aërial mycelium is produced in 1-month-old cultures. A light vinaceous cinnamon pionnotes develops at the outer edges of the twig.

Green bean pod.—Cultures 1 month old have a medium scant, white, cartridge buff, and pale pinkish buff mycelium. Salmon pionnotal masses may be produced.

Banana peel.—Cultures 1 month old have a medium dense, white mycelium.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Oat agar; culture 18 days old; conidia from pionnotes:
Conidia—
0-septate.
1-septate, 2 per cent.
2-septate, 1 per cent.
3-septate, 27 per cent.
4-septate, 13 per cent.
5-septate, 42 per cent, 58 by 3.5 (45 to 72 by 3.25 to 4) μ.
6-septate, 11 per cent.
7-septate, 2 per cent (70 to 93 by 3.5 to 4) μ.
8-septate, 2 per cent.

Hard potato agar; culture 8 days old; conidia from mycelium:
Conidia—
0-septate.
1-septate.
2-septate.
3-septate, 5 per cent, 35 by 2.75 (30 to 40 by 2.5 to 3) μ.
4-septate, 9 per cent, 35 by 2.75 (30 to 40 by 2.5 to 3) μ.
5-septate, 50 per cent, 46 by 3.5 (36 to 62 by 3.5) μ.
6-septate, 11 per cent
7-septate, 18 per cent
8-septate, 6 per cent
9-septate, 1 per cent
} (61 to 90 by 3 to 4) μ.

Potato-tuber plug; culture 1 month old; conidia from mycelium:
Conidia:
0-septate.
1-septate, 1 per cent, 19 by 3 (15 to 23 by 1.75 to 3.5) μ.
2-septate, 3 per cent, 24 by 3 (18 to 30 by 2.75 to 3.5) μ.
3-septate, 33 per cent, 29 by 3 (17 to 41 by 2.5 to 3.5) μ
4-septate, 9 per cent, 36 by 3 (32 to 42 by 2.75 to 3.5) μ.
5-septate, 48 per cent, 49 by 3 (40 to 58 by 2.5 to 3.5) μ.
6-septate, 3 per cent, 32 by 3.25 μ.
7-septate, 2 per cent, 75 by 3.25 (60 to 90 by 3) μ.
8-septate, 1 per cent.

Green bean pod; culture 17 days old; conidia from mycelium:
Conidia—
0-septate, 2 per cent, 19 by 3 μ.
1-septate, 13 per cent, 18 by 2.5 (14 to 23 by 2.25 to 2.75) μ.
2-septate, 2 per cent.
3-septate, 26 per cent, 31 by 4 (27 to 37 by 3.5 to 4.5) μ.
4-septate, 11 per cent, 41 by 4.75 (40 to 43 by 4.5 to 5.25) μ.
5-septate, 46 per cent, 48 by 5 (38 to 58 by 4 to 6) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 19 per cent, 32 by 3.25 (17 to 41 by 2.5 to 4.5) μ.
4-septate, 11 per cent, 37 by 3.5 (30 to 43 by 2.5 to 5.25) μ.
5-septate, 46 per cent, 50 by 3.75 (36 to 72 by 2.5 to 6) μ.
6- to 9-septate (60 to 93 by 3 to 4) μ.

The average measurements obtained were slightly narrower than those given by Sherbakoff. This is considered to be due to the fact that under certain conditions the conidia are broader than usual, as shown in the measurements on green bean pods. Neither were such long nor as many-septate spores obtained as described by Sherbakoff. It is believed that the cultures here described would under suitable conditions produce longer and larger conidia.

IV. Section GIBBOSUM Wollenweber

Gibbosum WOLLENWEBER, Phytopath. 3 (1913) 31; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 133; WOLLENWEBER, Ber. der Deutsch. Bot. Gesell. 35 (1918) 734.

Mycelium from white to brown; conidial mass typically pale buff to cinnamon and sepia; conidia in sporodochia and pionnotes, pale ochraceous to orange, dorsiventral sickle-shaped, elliptical with parabolic or hyperbolic curves, attenuate at both ends, pedicellate; sometimes smaller conidia in aërial mycelium, comma-shaped, 0- to 3-septate, rounded at both ends or slightly constricted, apedicellate; chlamydospores intercalary in mycelium and conidia; sclerotia rare, sometimes dark blue; stroma plectenchymic, ochraceous, chestnut brown, or carmine.

FUSARIUM BULLATUM Sherbakoff var. MINUS Wollenweber and Reinking. Plate 1, fig. 5; text fig. 8.

Fusarium bullatum minus WOLLENWEBER and REINKING, Phytopath. 15 (1925) 159.

Differs from the type species by smaller conidia; conidia in sporodochia or in pionnotes, pedicellate, mostly 3-septate, 27 to 35 by 3 to 4 μ; seldom 4- or 5-septate; 5-septate, 33 to 42 by 3.5 to 4.5 μ; conidia in aërial mycelium sometimes subnormal apedicellate, 3- (1- to 5-) septate.

Habitat.—On plant débris. Jamaica (*Hansford 14, R 233*).

The organism was not isolated by Reinking, but was obtained through the courtesy of Mr. C. G. Hansford, of Jamaica.

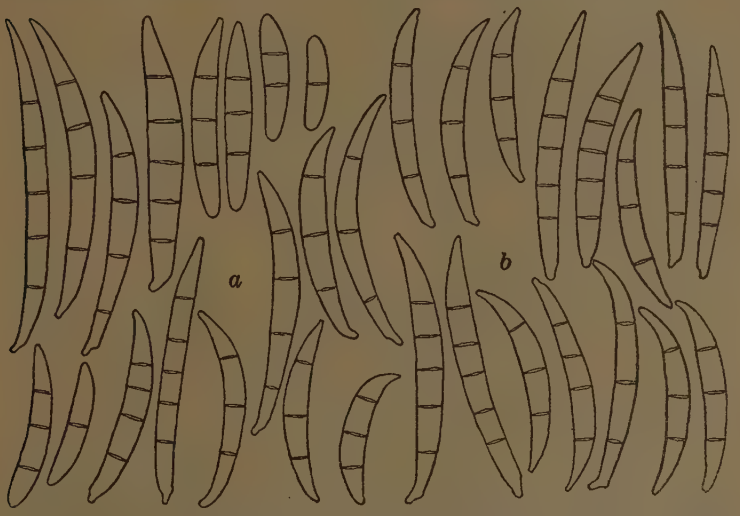

FIG. 8. *Fusarium bullatum* Sherbakoff var. *minus* Wollenweber and Reinking; *a*, conidia from sporodochia of 14-day-old *Alnus*-stem culture; *b*, conidia from mycelium and pionnotes of 1-month-old potato-tuber plug culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—In 2-month-old potato-agar tubes a white, medium thin, matted growth is produced over the slant. On potato-agar plates of the same age the aërial growth is scant and pale pinkish buff.

Oat agar.—Cultures 1 month old have a dense, matted, felty growth that is white and cartridge buff above and pale cinnamon pink at the base.

Rice.—On cultures 2 months old a white, medium dense mass of mycelium is produced.

Potato-tuber plug.—Cultures 2 months old have a whitish, matted, felty, and leathery growth over the potato.

Melilotus stem.—On stems 1 month old a medium scant, fine, cottony, white mycelium is produced.

Alnus stem.—One-month-old culture has a white and pale pinkish cinnamon, dense mycelial growth on the top of the stem and a medium scant and fine woolly growth over sides. Pinkish cinnamon tuberculate sporodochia may be produced in abundance over the stem.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Potato-tuber plug; cultures 1 month old; conidia from mycelium:
Conidia—
0-septate.
1-septate, 8 per cent.
2-septate, 7 per cent.
3-septate, 80 per cent, 32 by 3.5 (29 to 35 by 3 to 4) μ.
4-septate, 3 per cent.
5-septate, 2 per cent, 39 by 4 (36 to 42 by 3.5 to 4.5) μ.

Alnus stem; culture 14 days old; conidia from sporodochia:
Conidia—
0-septate, rare.
1-septate, 1 per cent.
2-septate, rare.
3-septate, 97 per cent, 30 by 3.5 (21 to 40 by 3 to 4) μ.
4-septate, 1 per cent, 37 by 3.5 (30 to 45 by 3.5 to 3.75) μ.
5-septate, 1 per cent, 37 by 3.75 (33 to 42 by 3.5 to 4.25) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 90 per cent, 31 by 3.5 (21 to 40 by 3 to 4) μ.
4-septate, 2 per cent, 37 by 3.5 (30 to 45 by 3.5 to 3.75) μ.
5-septate, 2 per cent, 38 by 3.75 (33 to 42 by 3.5 to 4.5) μ.

FUSARIUM BULLATUM Sherbakoff var. BREVIUS Wollenweber and Reinking. Text fig. 9.

Fusarium bullatum brevius WOLLENWEBER and REINKING, Phytopath. 15 (1925) 160.

Differs from the type species by shorter conidia, 5- (3- to 5-) septate; 5-septate, 31 to 44 by 3 to 4 μ; 3-septate, 21 to 36 by 2.5 to 3.5 μ; chlamydospores intercalary in mycelium and conidia, 1-celled, 2-celled, in clusters.[5]

Habitat.—On dead hibiscus stems (*Hibiscus rosa-sinensis* Linnæus) and decaying banana leaves and plant parts (*Musa sapientium* Linnæus (*R 47*). Tela, Honduras, Central America (*Reinking R 47*).

[5] From *F. bullatum* var. *minus* it differs by higher-separated and a little broader conidia.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—On 12-day-old agar slants pale pinkish buff, dense mycelium is produced in places. At the base it may be buckthorn brown. Salmon and salmon buff patches of pionnotes may be produced here and there. Older cultures, up to 3 months of age, have a scant white to cartridge buff and light pinkish cinnamon and cinnamon mycelium. Pinkish cinnamon and cinnamon pionnotes masses may be present. On 2-month-old agar plates a white, thin, zonate, matted mycelium is present.

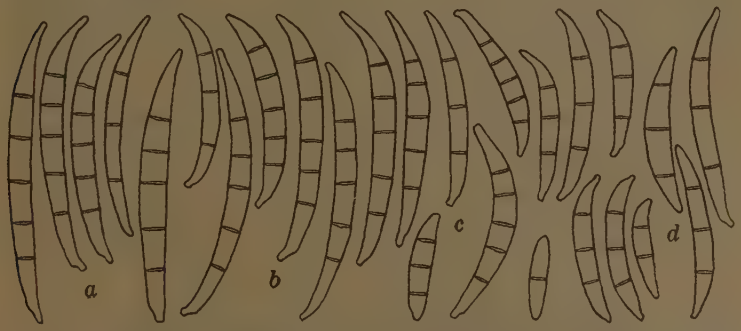

FIG. 9. *Fusarium bullatum* Sherbakoff var. *brevius* Wollenweber and Reinking; *a*, conidia from pionnotes of 8-day-old hard potato-agar culture; *b*, conidia from pionnotes of 7-day-old oatmeal-agar culture; *c*, conidia from pionnotes of 5-day-old hard potato-agar culture; *d*, conidia from pionnotes of 8-day-old *Melilotus*-stem culture.

Oat agar.—In tubes 1 month old a pale pinkish buff, dense, matted mycelium is produced on the slant. Tawny olive and Saccardo's umber may be present in spots, especially at the base. A light vinaceous cinnamon pionnotes may be produced.

Potato-agar plate, 5 per cent dextrose.—A pinkish cinnamon, medium dense, matted mycelium is produced after one month's growth. The substratum is clay color and tawny olive.

Rice.—Cultures 19 days old have a pale ochraceous buff, cinnamon buff and clay color, dense, matted mycelium above. At the base and sides the mycelium may be chestnut brown and pale salmon color when conidia are produced. Cultures 2 months old are snuff brown and bister on top with a leathery mycelium. On the sides the growth may be pale pinkish buff and cinnamon buff and at the base pale cinnamon pink. Flesh ocher spots may also be present. A pinkish buff pionnotes may be found in places.

Potato-tuber plug.—Cultures 3 months old are light buff on top with cinnamon buff and clay color. An ochraceous salmon

or pale pinkish buff pionnotes may be present. Cultures between 2 and 3 months old have a pinkish buff, cinamon buff, felty mycelium in places. At the base the mycelium is leathery and tawny olive with Saccardo's umber. Blackish brown(3) plectenchymic bodies may be present in places.

Melilotus stem.—Two-month-old growth is characterized by a pale pinkish buff, dense, matted mycelium over the stem.

Alnus stem.—One-month-old growth is characterized by a pale pinkish buff, scant mycelium that is powdery in places. A pinkish buff pionnotes may be produced.

Green bean pod.—Green bean-pod cultures 1 to 2 months old have a cartridge buff, cream buff, pinkish buff, and cinnamon buff, dense, matted, mycelial growth.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; cultures 12 days old; conidia from pionnotes:
Conidia—
0-septate.
1-septate, 5 per cent, 16 by 2.5 (14 to 18 by 2.25 to 2.75) μ.
2-septate, 3 per cent, 19 by 2.75 (19 by 2.5 to 3.5) μ.
3-septate, 50 per cent, 29 by 3 (22 to 34 by 2.5 to 3.5) μ.
4-septate, 18 per cent, 30 by 3.5 (25 to 40 by 3 to 4) μ.
5-septate, 24 per cent, 35 by 3.5 (28 to 45 by 3 to 4) μ.

Oat agar; culture 2 weeks old; conidia from pionnotes:
Conidia—
3-septate, 7 per cent, 28 by 3 (21 to 36 by 2.5 to 3.75) μ.
4-septate, 5 per cent.
5-septate, 88 per cent, 38 by 3.5 (31 to 45 by 3 to 4) μ.

Rice; culture 50 days old; conidia from pionnotes:
Conidia—
3-septate, 30 by 2.6 (25 to 36 by 2.5 to 2.75) μ.
4-septate.
5-septate, 38 by 3.5 (33 to 44 by 3 to 4) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—
3-septate, 28 per cent, 29 by 3 (21 to 36 by 2.5 to 3.75) μ
4-septate, 12 per cent, 30 by 3.5 (25 to 40 by 3 to 4) μ.
5-septate, 56 per cent, 37 by 3.5 (28 to 45 by 3 to 4) μ.

FUSARIUM BULLATUM Sherbakoff. Text fig. 10.

Fusarium bullatum SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 198; WOLLENWEBER and REINKING, Phytopath. 15 (1925) 159.

Sherbakoff has described this fungus under his section *Ferruginosum* with sickle-shaped, pedicellate, mostly 5-septate, 42

by 4.3 (31 to 47 by 4.1 to 4.9) μ, cream or salmon color conidia; chlamydospores intercalary, in chains or in clusters; stroma from hyaline to pale golden.

Habitat.—On dead floral parts at the tip of banana fruit (*Musa sapientium* Linnæus) (*R 54*), in the air and soil. Tela, Honduras, Central America (*Reinking R 54*).

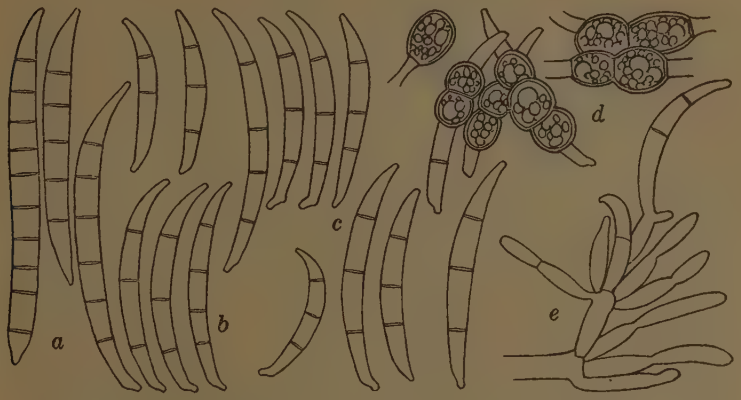

FIG. 10. *Fusarium bullatum* Sherbakoff; *a*, conidia, large, straight, nonpedicellate, from pionnotes in mycelium of 6-day-old hard potato-agar culture; *b*, conidia, smaller, pedicellate, from pionnotes and mycelium of 5-day-old hard potato-agar culture; *c*, conidia from pionnotes in mycelium of 6-day-old hard potato-agar culture; *d*, chlamydospores from 8-month-old hard potato-agar culture; *e*, conidiophore from 5-day-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

The growth on various media is similar to that discussed under *F. bullatum* var. *brevius* Wollenweber and Reinking.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 6 days old; conidia from pionnotes:
Conidia—
3-septate, 23 per cent, 35 by 3 (32 to 40 by 3 to 3.25) μ.
4-septate, 16 per cent, 33 by 3.75 (29 to 44 by 2.75 to 5) μ.
5-septate, 61 per cent, 37 by 4 (29 to 47 by 3 to 4.5) μ.

Oat agar; culture 14 days old; conidia from pionnotes:
Conidia—
3-septate, 20 per cent.
4-septate, 27 per cent.
5-septate, 53 per cent.

Melilotus stem; culture 14 days old; conidia from pionnotes:
Conidia—
5-septate, 44 by 3.5 (40 to 48 by 3.5 to 3.75) μ.

Green bean pod; culture 12 days old; conidia from mycelium and pionnotes:

Conidia—

1-septate, 2 per cent, 17 by 3.5 (16 to 18 by 3 to 4) μ.
2-septate, 1 per cent, 21 by 3.5 μ.
3-septate, 62 per cent, 27 by 4 (18 to 36 by 3.25 to 4.5) μ.
4-septate, 29 per cent, 38 by 4 (32 to 45 by 3.5 to 4.5) μ.
5-septate, 6 per cent, 35 by 4.5 (33 to 43 by 4 to 5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—

3-septate, 35 per cent, 33 by 3.75 (18 to 40 by 2.5 to 4.5) μ.
4-septate, 21 per cent, 36 by 3.75 (29 to 45 by 2.75 to 5) μ.
5-septate, 40 per cent, 39 by 4 (29 to 48 by 3 to 5) μ.

FUSARIUM OSSICOLUM (Berkeley and Curtis) Saccardo. Plate 1, fig. 6; text fig. 11.

Fusarium ossicolum SACCARDO, Syll. Fung. 4 (1886) 714; WOLLENWEBER, Ann. Myc. 15 (1917) 15.

Light orange mycelium and conidial mass; conidia in sporodochia and pionnotes, curved spindle-shaped, sickle-shaped, middle cells broad in comparison with the longer end cells, end cell often slender, pointed and often curved; 5- (3- to 5-) septate, 27 to 48 by 3.75 to 4.5 μ; 0-septate, 9 to 11 by 3 to 4.5 μ; 3-septate, 23 to 26 by 3.75 μ; 4-septate, 23 to 26 by 4.5 to 6.25 μ; chlamydospores, intercalary or sometimes terminal.

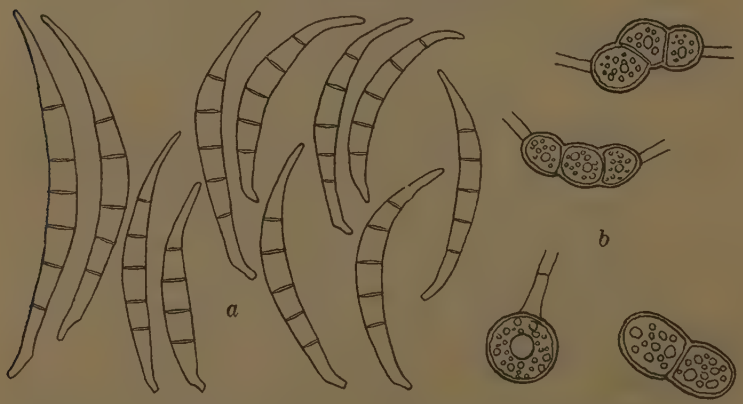

FIG. 11. *Fusarium ossicolum* (Berkeley and Curtis) Saccardo; *a*, conidia from pionnotes of 1-month-old oatmeal-agar culture; *b*, chlamydospores, terminal and intercalary, from 1-month-old hard potato-agar culture.

Habitat.—On decaying banana leaves (*Musa sapientium* Linnæus). Jamaica (*Hansford 18, R 237*).

The fungus was not isolated by Reinking, but was obtained through the courtesy of Mr. C. G. Hansford, of Jamaica.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 3 months old on agar have a white, medium dense, thin cottony mycelium. Pinkish buff pionnotes masses are present in places. Growth on 2-month-old potato-agar plates is pale cinnamon pink and medium thin. Light vinaceous cinnamon and pinkish cinnamon mycelium may be produced.

Potato-agar plate, 5 per cent dextrose.—The aërial mycelium is thick, matted, felty, and pale pinkish buff, cinnamon buff, and tawny olive. The mycelium in the substratum is russet.

Oat agar.—Cultures 1 month old have a white and pale cinnamon pink, dense, felty, mycelial growth with sayal brown and snuff brown in spots at the base of the slant where it touches the glass. A vinaceous cinnamon pionnotes may be produced.

Rice.—Cultures 2 months old have a dense, matted mycelium that is snuff brown on top, bone brown at the base, and chocolate in places.

Potato-tuber plug.—Cultures 2 months old have a growth similar to that on rice.

Melilotus stem.—Cultures 1 month old have a dense, thick, fine, cottony, pinkish buff mycelium over the stem.

Alnus stem.—Cultures 1 month old have a dense, thick, pinkish buff, pale pinkish cinnamon, and cinnamon buff mycelium in places over the twigs. A light pinkish cinnamon pionnotes may be produced in spots.

MEASUREMENTS OF CONIDIA

Oat agar; culture 1 month old; conidia from pionnotes:
Conidia—
0-septate, 6 per cent, 10 by 3.75 (9 to 11 by 3 to 4.5) μ.
1-septate.
2-septate.
3-septate, 9 per cent, 24 by 3.75 (23 to 26 by 3.75) μ.
4-septate, 6 per cent, 24 by 4.75 (23 to 26 by 4.5 to 5.25) μ.
5-septate, 79 per cent, 36 by 4.25 (27 to 48 by 3.75 to 4.5) μ.

FUSARIUM FALCATUM Appel and Wollenweber. Text fig. 12.

Fusarium falcatum APPEL and WOLLENWEBER, Arb. Kais. Biol. Anst. Land- u. Forstw. 8 (1910) 175–185; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 135; WOLLENWEBER, Ann. Myc. 15 (1917) 15.

Mycelium white to ocher. Conidial masses ocher, yellowish brown, or reddish ocher. Conidia, sporodochia, and pionnotes present; curved spindle-shaped, sickle-shaped, middle cells very broad in comparison with the much longer end cells, with long

and narrow apex, prominently pedicellate, parabolic to hyperbolic curved, typically 5- (3- to 5-) septate, 46 by 4.75 (36 to 65 by 3.5 to 6) μ; 3-septate, 27 by 4 (23 to 32 by 3.5 to 4.5) μ; 4-septate, 37 by 4 (29 to 42 by 3.5 to 4.5) μ; rarer 6- to 12-septate; 10-septate, 83 by 5.5 μ; chlamydospores 6 to 14 μ in diameter, intercalary or sometimes terminal in mycelium and conidia; 1-celled, 2-celled, in chains or in masses.

Habitat.—In soil, Trujillo, Honduras, Central America (*Reinking R 208*). In plant débris, Jamaica (*Hansford 15, R 234*).

Fusarium falcatum has been determined to be a wound parasite causing tomato fruit rot in Germany and the United States.

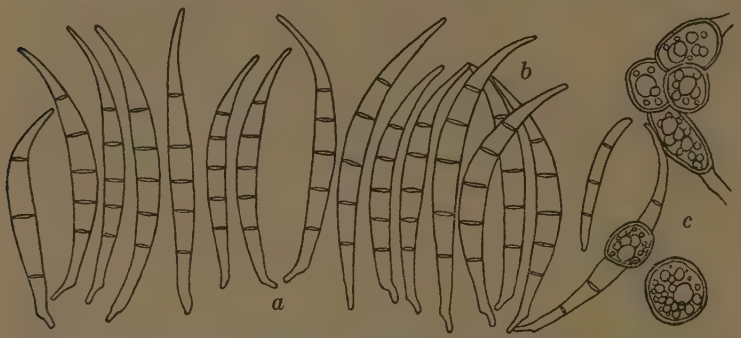

FIG. 12. *Fusarium falcatum* Appel and Wollenweber; *a*, conidia from sporodochia of 1-month-old *Alnus*-stem culture; *b*, conidia from pionnotes of 5-day-old hard potato-agar culture; *c*, chlamydospores from 15-day-old water culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 2 months old have a scant white mycelium with pale pinkish buff pionnotes over slant. The same type of growth is produced on plates of potato agar 2 months old.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a scant sayal brown aërial mycelium and snuff brown pionnotes. The substratum is snuff brown.

Oat agar.—Cultures 1 month old have a white and pale pinkish buff, medium dense, and matted mycelium over the slant. It may be flattened and cream buff in places.

Rice.—Cultures 2 months old have a snuff brown or bone brown mycelium on top and light vinaceous cinnamon on sides. A light vinaceous cinnamon pionnotes is produced.

Potato-tuber plug.—Cultures 2 months old have a white, medium thin, matted mycelium over the plug. The mycelium may be cartridge buff and cream buff in places.

Melilotus stem.—Cultures 2 months old have a scant, cream buff mycelium on the top of the stem and a pionnotes over the sides of the stem.

Alnus stem.—Cultures 1 month old have a medium dense, fine cottony, pale pinkish cinnamon, and cinnamon buff mycelium in places over the stem.

Green bean pod.—Cultures 2 months old have a scant, pale pinkish buff and pinkish buff mycelium over the bean. A cinnamon pionnotes may be present in places.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 1 month old; conidia from pionnotes:
Conidia—
3-septate, 5 per cent, 26 by 3.75 (25 to 27 by 3.5 to 4) μ.
4-septate, 11 per cent, 33 by 4 (29 to 39 by 3.5 to 4.5) μ.
5-septate, 84 per cent, 40 by 4 (31 to 45 by 3.5 to 4.5) μ.

Hard potato agar; culture 5 days old; conidia from pionnotes:
Conidia—
3-septate, 12 per cent.
4-septate, 33 per cent, 38 by 4 (35 to 42 by 3.75 to 4) μ.
5-septate, 55 per cent, 43 by 4 (39 to 50 by 3.75 to 4.5) μ.

Alnus stem; culture 21 days old; conidia from pionnotes:
Conidia—
5-septate, 42 by 4 (35 to 48 by 3.5 to 4.5) μ.

Green bean pod; cultures 1 month old; conidia from pionnotes:
Conidia—
3-septate, 6 per cent, 28 by 4.25 (23 to 32 by 4 to 4.5) μ.
4-septate, 6 per cent, 39 by 4.25 (36 to 42 by 4 to 4.5) μ.
5-septate, 88 per cent, 41 by 4.25 (33 to 50 by 4 to 4.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—
3-septate, 8 per cent, 27 by 4 (23 to 32 by 3.5 to 4.5) μ.
4-septate, 17 per cent, 37 by 4 (29 to 42 by 3.5 to 4.5) μ.
5-septate, 75 per cent, 42 by 4 (31 to 50 by 3.5 to 4.5) μ.

FUSARIUM ACUMINATUM Ellis and Everhart emend. Wollenweber. Text fig. 13.

Fusarium acuminatum ELLIS and EVERHART, Proc. Acad. Sci. Phila. (1895) 441; SACCARDO, Syll. Fung. 14 (1899) 1125–1126; WOLLENWEBER, Journ. Agr. Research 2 (1914) 269–270.

Conidia scattered, in sporodochia or in pionnotes, orange in mass; conidia average as follows: 5-septate, 40 to 70 by 3 to 4 μ; 4-septate (less common), 30 to 60 by 3 to 4.5 μ; 3-septate, 20 to 45 by 2.75 to 4.25 μ; 0, 1, 2, 6, and 7 septations occasionally found; subnormal small conidia may be mistaken for conidia of the section *Discolor*, but normal sporodochia develop on repeatedly whorl-like branched conidiophores, giving the character-

istic conidia of the section *Roseum;* conidia in side view, with hyperbolic or parabolic curves, in contrast to *Fusarium herbarum* (Corda) Fries, the conidia of which are less curved; chlamydospores present, intercalary in mycelium and conidia, sometimes single, but mostly in chains and clusters; blue, globose sclerotia, 50 to 70 μ thick, form a striking contrast to the carmine plectenchymatic thallus on starchy media, such as steamed potato tubers. Both blue and carmine are basic modifications of the fungus, while yellow (on rice) is the acid one, turning blue to purple-violet with the addition of an alkali.

FIG. 13. *Fusarium acuminatum* Ellis and Everhart emend. Wollenweber; *a*, conidia from mycelium of 16-day-old oatmeal-agar culture; *b*, chlamydospores from mycelium of 2-month-old hard potato-agar culture.

Habitat.—Spores of the fungus were isolated from the air. Tela, Honduras, Central America (*Reinking R 105*).[6]

Fusarium acuminatum, formerly placed in section *Roseum,* has been placed under the section *Gibbosum* because the conidia have the parabolic dorsal and ventral curvature which is characteristic of this section. Further studies of various strains have led to the observation of intercalary chlamydospores in the mycelium and conidia of this fungus, a character that is also required for the section *Gibbosum.* The presence of carmine mycelium, however, is not a definite character for the section *Roseum* alone as it has been found present in *F. acuminatum* and *F. longipes,* both of which can only be placed in the section *Gibbosum.* These species may be regarded as border-line forms

[6] *R 105* produced conidia of an average length slightly less than that of the type strain, but the differences in important characters do not warrant separating it as a variety.

with carmine mycelium, otherwise with characters of the section *Gibbosum*, but closely related to those in the section *Roseum*.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old have a white and ivory yellow, thick, dense, matted mycelium over agar with cream buff and buckthorn brown in a few places where it touches the glass. The agar is usually turned spinel red in some places. On potato-agar plates a medium scant, pinkish buff, woolly mycelium is produced.

Potato-agar plate, 5 per cent dextrose.—Cultures 17 days old have a medium dense, matted, pale cinnamon pink aërial mycelium. The mycelium in the substratum is a light vinaceous cinnamon.

Oat agar.—Cultures 17 days old are characterized by an aërial mycelium that is medium dense, matted, and white to pale pinkish cinnamon. On the edges of the slant a rose color and pomegranate purple plectenchymic stroma is usually produced. The agar may be turned coral red in places.

Rice.—Cultures 19 days old have a dense matted mycelium that is white above and mustard yellow and primuline yellow in places. Spots of vinaceous rufous may be present where the mycelium touches the glass. Two-month-old cultures are pinkish buff, cinnamon buff with Indian lake, tawny olive, or Verona brown in places. The mycelium is usually leathery at the base.

Potato-tuber plug.—Cultures 1 to 2 months old have a dense, matted, white mycelium on top with spots of pomegranate purple and Bordeaux red in places below. The oldest cultures may also have Dresden brown and mummy brown in spots.

Green bean pods.—Cultures 1 to 2 months old have a medium scant, matted, white, and cartridge buff mycelium.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 2 months old; conidia from mycelium and pionnotes:

Conidia—

1-septate, 4 per cent, 17 by 3.5 (16 to 18 by 3 to 4) μ.
2-septate, 1 per cent, 26 by 4 μ.
3-septate, 30 per cent, 38 by 4 (31 to 45 by 3.25 to 4.5) μ.
4-septate, 25 per cent, 35 by 3.5 (31 to 46 by 3.25 to 3.75) μ.
5-septate, 40 per cent, 39 by 4 (31 to 45 by 3.25 to 4.5) μ.

Oat agar; culture 16 days old; mycelium and pionnotes:
Conidia—
5-septate, 38 by 4 (33 to 45 by 3.75 to 4.5) μ.
Rice; culture 1 month old; conidia from plectenchymic stroma:
Conidia—
3-septate, 29 per cent, 31 by 3.25 (30 to 32 by 3.25) μ.
4-septate, 28 per cent, 31 by 3.25 (30 to 32 by 3.25) μ.
5-septate, 43 per cent, 35 by 4 (31 to 40 by 3.25 to 4.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 30 per cent, 35 by 3.75 (30 to 45 by 3.25 to 4.5) μ.
4-septate, 26 per cent, 33 by 3.5 (30 to 46 by 3.25 to 3.75) μ.
5-septate, 42 per cent, 37 by 4 (31 to 45 by 3.25 to 4.5) μ.

FUSARIUM CAUDATUM Wollenweber. Text fig. 14.

Fusarium caudatum WOLLENWEBER, Journ. Agr. Research 2 (1914) 262–263.

Conidia with a tail or whiplike prolongated apical cell and a pedicellate base with well-marked heel, ocherous to salmon color

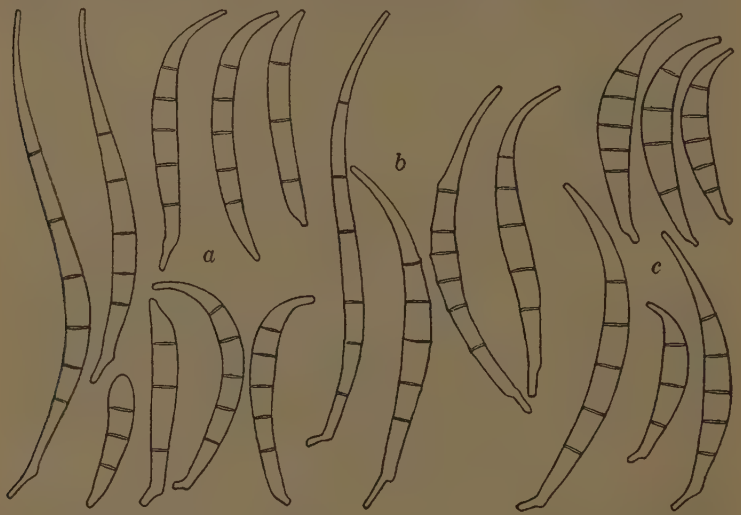

FIG. 14. *Fusarium caudatum* Wollenweber; *a*, conidia, long type, from sporodochia of 56-day-old rice culture; *b*, conidia from pionnotes of 15-day-old hard potato-agar culture; *c*, conidia, short type, from pionnotes of 17-day-old *Melilotus*-stem culture.

in mass, formed in sporodochia and in pionnotes; 5-septate conidia averaging 40 to 80 by 3 to 4.5 μ, lower and higher septations more rarely occur; chlamydospores brown, 7 to 14 μ in diameter, as a rule intercalated in chains or clusters, but frequently single if formed from the content of the cells of conidia under poor conditions, such as in water.

Habitat.—Soil. Jamaica (*Hansford 19a, R 238*). The culture was not isolated by Reinking, but was obtained through the courtesy of Mr. C. G. Hansford, of Jamaica.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—In tubes of hard potato agar 2 months old a medium thin, cottony white mycelium, matted in places, is produced. Light pinkish cinnamon sporodochia and pionnotes masses may be produced in abundance.

Oat agar.—Cultures 1 month old have a scant, fine, cottony, white mycelium. The main part of the slant is covered with a flesh ocher and rufous pionnotes composed of small sporodochia.

Rice.—Cultures 2 months old have a scant, aërial, white and salmon color mycelium on rice. The rice is covered with a flesh ocher and rufous pionnotes.

Potato-tuber plug.—Cultures 2 months old have a matted, white and cinnamon buff mycelium over the potato.

Melilotus stem.—Cultures 1 month old have a scant pinkish buff aërial mycelium on the top of the stem. The sides of the stem are covered with a vinaceous cinnamon pionnotes.

Alnus stem.—Cultures 1 month old are characterized by having a scant pinkish cinnamon mycelium on the top of the twig and a light pinkish cinnamon pionnotes in places over the sides.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Rice; culture 56 days old; conidia from sporodochia.
Conidia—
3-septate, 6 per cent, 27 by 3.75 (21 to 33 by 3.5 to 4) μ.
4-septate, 22 per cent, 32 by 4 μ.
5-septate, 69 per cent, 52 by 3.75 (32 to 74 by 3.5 to 4) μ.
6-septate, 3 per cent, 74 by 3.75 μ.

Melilotus stem; culture 17 days old; conidia from pionnotes:
Conidia—
3-septate, 2 per cent, 25 by 4.5 (24 to 25 by 4.5 μ.
4-septate, 29 per cent, 32 by 4.5 μ.
5-septate, 69 per cent, 36 by 4.5 (27 to 44 by 4 to 5) μ.

Potato agar; culture 15 days old; conidia from pionnotes:
Conidia—
5-septate, 47 by 4 (41 to 52 by 3.5 to 4.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 4 per cent, 26 by 4 (21 to 33 by 3.5 to 4.5) μ.
4-septate, 26 per cent, 32 by 4.25 (32 by 4 to 4.5) μ.
5-septate, 69 per cent, 45 by 4 (27 to 74 by 3.5 to 5) μ.
6-septate, 1 per cent, 74 by 3.75 μ.

FUSARIUM LONGIPES Wollenweber and Reinking. Plate 1, fig. 7; text fig. 15.

Fusarium longipes WOLLENWEBER and REINKING, Phytopath. 15 (1925) 160.

Stroma spread out or verrucose erumpent, aërial mycelium from white to carmine and ochraceous; conidia in sporodochia and in pionnotes, sometimes in columns, ochraceous to orange, elongate sickle-shaped, parabolically or hyperbolically curved, attenuate with whiplike top end sometimes very much curved, footed basal cell long, 5- (4- to 6-) septate, 63 to 104 by 2.75 to 4 μ; smaller conidia in aërial mycelium with a short-footed base; 5-septate, 36 to 53 by 3 to 4 μ; chlamydospores sometimes spined, subverrucose, intercalary, mostly singular, 6 to 9 μ in diameter.

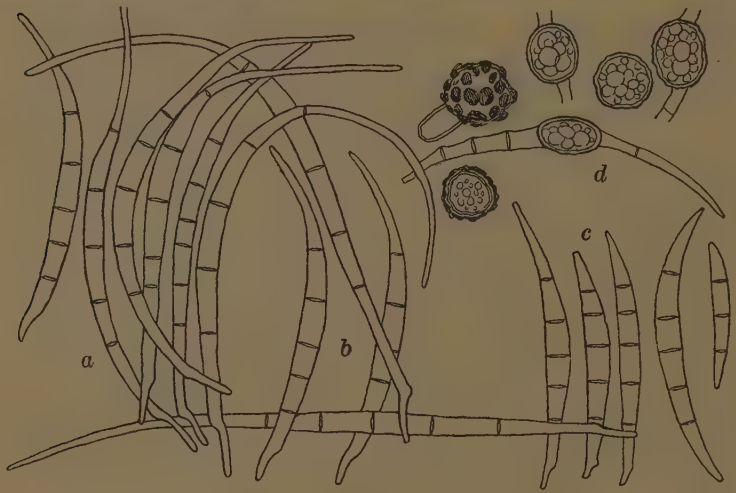

FIG. 15. *Fusarium longipes* Wollenweber and Reinking; *a*, conidia, typical type, from pionnotes of 3-month-old hard potato-agar culture; *b*, conidia, short type, from pionnotes of 6-day-old hard potato-agar culture; *c*, conidia, short type, from sporodochia of 1-month-old *Alnus*-stem culture; *d*, chlamydospores from 3-month-old hard potato-agar culture and 15-day-old water culture.

Differs from *F. filiferum* (Preuss) Wollenweber in having conidia that are not so broad and in the production of a carmine mycelium.

Habitat.—On mature and living leaves of banana (*Musa sapientium* Linnæus). Tela, Honduras, Central America (*Reinking R 34*).

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a white, rose color, and pomegranate purple with a Bordeaux ring at the base, thick, dense, and matted mycelium. Older cultures, up to 3 months of age, have a similar mycelial formation, but with the addition of light ochraceous buff sporodochial masses in the center of the growth. The sporodochia may be in columns up to 6 mm long. On potato-agar plates 2 months old a medium thin, white mycelium is present over the top of the plate. Light ochraceous salmon sporodochia are also produced. The mycelium in the substratum is zonate with concentric rings of pale pinkish buff and spinel red mycelium.

Potato-agar plate, 5 per cent dextrose.—One-month-old plates have a medium dense, thick, matted, cameo pink, and spinel red mycelium over the surface. The mycelium in the substratum is spinel pink and spinel red.

Oat agar.—Cultures 1 month old have a thick, dense, matted, white, pale cinnamon pink, seashell pink, pomegranate purple, and Bordeaux mycelium. Apricot buff pionnotes masses are produced over the mycelium in places.

Rice.—Nineteen-day-old cultures have a medium dense, matted mycelium, white above, and lower a pomegranate purple. The mycelium may be also in places pale flesh color, cadmium yellow, and raw sienna. Two-month-old cultures are the same, with the addition of yellow ocher, buckthorn brown, cinnamon brown, and mummy brown in places. Vinaceous cinnamon sporodochia, sometimes in columns, are usually produced.

Potato-tuber plug.—Cultures 1 month old have an aërial, cottony, or dense, matted, white mycelium with pomegranate purple coloration at the base. Older cultures, up to 80 days old, are in the main the same, however, with a leathery mycelium that is cartridge buff, dark olive gray, and pomegranate purple in places.

Melilotus stem.—Cultures 1 month old have a medium dense, pale ochraceous buff mycelium over the stems. Few ochraceous salmon sporodochia are produced.

Alnus stem.—Cultures 1 month old have a scant pale ochraceous buff mycelium in places over the stem. Light ochraceous salmon sporodochia develop from the lenticels of the twig.

Green bean pod.—Cultures between 2 and 3 months old have a dense, matted and leathery, white, cartridge buff, pinkish buff, with spots of pomegranate purple mycelium over the pod.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 12 days old; conidia from sporodochia:
Conidia—
4-septate, 3 per cent, 63 by 3.5 μ.
5-septate, 94 per cent, 72 by 4 (63 to 79 by 3.75 to 4) μ.
6-septate, 3 per cent, 94 by 4 μ.
Hard potato agar; culture 9 days old; conidia from sporodochia:
Conidia—
5-septate, 100 per cent, 86 by 3.75 (73 to 104 by 3.5 to 4) μ.
Alnus stem; culture 1 month old; conidia from sporodochia:
Conidia—
4-septate, 12 per cent.
5-septate, 88 per cent, 45 by 3.5 (36 to 53 by 2.75 to 4) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
4-septate, 5 per cent, 63 by 3.5 μ.
5-septate, 94 per cent, 79 by 3.75 (63 to 104 by 2.75 to 4) μ.
6-septate, 1 per cent, 94 by 4 μ.

VII. Section ROSEUM Wollenweber

Roseum WOLLENWEBER, Phytopath. 3 (1913) 32; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 142; WOLLENWEBER, Ber. der Deutsch. Bot. Gesell. 35 (1918) 739.

Conidia broad ellipsoid, typically of an even diameter for a considerable part of their length, comparatively narrow, very gradually attenuate toward both ends, approaching sickle-shape, top cell long, sometimes narrow filiform, base more or less pedicellate; chlamydospores absent; some species have blue sclerotia. Color type, acid color modification of aëral mycelium yellow except in *Fusarium anthophilum* and other related fungi.

FUSARIUM ANTHOPHILUM (A. Braun) Wollenweber. Plate 1, fig. 8; text fig. 16.

Fusarium anthophilum BRAUN, Rabenhorst Fungi Europaei, No. 1964 (1875); WOLLENWEBER, Ann. Myc. 15 (1917) 14; WOLLENWEBER and REINKING, Phytopath. 15 (1925) 160.

Stroma pale, never carmine, conidia scattered, in pionnotes, seldom in sporodochia, slender, attenuate at both ends, sickle-shaped, similar to *F. herbarum* Corda, pedicellate, 3- to 5-septate, 35 to 70 by 2.5 to 4 μ (30 to 82 by 2.5 to 4.5) μ, rarely 6- to more-septate, scattered conidia lanceolate, slightly curved, attenuate at both ends, apedicellate or appendicular; chlamydospores absent.

Habitat.—On dead inflorescence of Rangpur lime (*Citrus aurantifolia* Swingle), on dead leaves of carrot (*Daucus carota* Linnæus), on decaying peduncle and plant trash of banana (*Musa sapientium* Linnæus), on dried pod of bush bean (*Phaseolus vulgaris* Linnæus), on dead cacao twigs (*Theobroma cacao* Linnæus) (*R 97*), and in soil and air. Tela, Honduras, Central America (*Reinking R 97*).

FIG. 16. *Fusarium anthophilum* (A. Braun) Wollenweber; *a*, conidia, long type, from pionnotes of 14-day-old oatmeal-agar culture; *b*, conidia from mycelium of 10-day-old hard potato-agar culture; *c*, conidia, short type, from pionnotes of 34-day-old rice culture; *d*, conidia and conidiophore from sporodochia of 34-day-old *Melilotus*-stem culture.

Fusarium anthophilum (A. Braun) Wollenweber is common on decaying and dead parts of various hosts. It can also be generally isolated from soil and air. Its pathogenicity has not been fully tested. Soil inoculations about banana plants failed to produce infection.(7)

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 2 to 11 days old have a dense, chiefly pale pinkish buff with tawny olive mycelium. Salmon buff and salmon pionnotes masses may be produced. Older cultures, up to 3 months old, are medium dense to matted and light buff, light pinkish cinnamon with buckthorn brown, cin-

namon brown, and mummy brown in places. The pionnotes in older cultures is light pinkish cinnamon.

Oat agar.—Cultures 1 month old have a dense, matted, pale pinkish buff aërial mycelium with pinkish buff and cinnamon buff on the sides of the slant.

Rice.—Cultures 20 days old are characterized by having a medium dense and matted, pale pinkish buff and pinkish buff mycelium. The mycelium also may be in places buckthorn brown and flesh color around the edge of the rice on the glass. Older cultures, from 1 to 2 months old, are leathery and at first Verona brown, pinkish cinnamon, and vinaceous cinnamon, and later pale pinkish buff or pinkish buff with buckthorn brown at the base, and flesh color around the edge of the rice on the glass. A light buff, salmon buff, or even apricot orange pionnotes may be produced.

Potato-tuber plug.—Cultures 21 days old have a dense matted, felty, white, pale ochraceous salmon mycelium with seashell pink, clay color or sepia where it touches the glass. Older cultures, from 1 to 3 months old, are dense, matted, leathery in places, cartridge buff, warm buff, and chamois at first, later turning to ivory yellow, pinkish buff, cinnamon buff, or wood brown. The growth in the oldest cultures may be leathery and wrinkled. A light ochraceous salmon pionnotes may be present.

Melilotus stem.—Cultures 2 months old have a medium dense, pale pinkish buff mycelium with yellow ocher where it touches the glass.

Alnus stem.—Cultures 1 month old have a medium scant, pale pinkish cinnamon mycelium. A light vinaceous cinnamon pionnotes is usually produced.

Banana peel.—Cultures 26 days old have a scant, cottony, white and pinkish buff mycelium. Older cultures, 3 months old, have no aërial mycelium, but have a cinnamon pionnotes and blackish green-gray sclerotia in wartlike heaps, 0.5 to 4 mm in diameter.

Green bean pod.—Cultures 16 days old have a dense, matted, light buff and buckthorn brown mycelium with a light ochraceous salmon pionnotes. Older cultures, between 1 and 2 months old, are primarily characterized by a medium dense, matted, cartridge buff mycelium with pale pinkish cinnamon, cream buff, and chamois in places.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 18 days old; conidia from pionnotes:
Conidia—
1-septate, 2 per cent, 16 by 2.75 μ.
2-septate.
3-septate, 23 per cent, 26 by 3.5 (18 to 30 by 3 to 4) μ.
4-septate, 19 per cent, 40 by 3.5 (32 to 45 by 3 to 4) μ.
5-septate, 56 per cent, 44 by 3.75 (36 to 50 by 3.5 to 4) μ.

Hard potato agar; culture 30 days old; conidia from mycelium:
Conidia—
0-septate, 2 per cent, 11 by 2.75 (11 to 12 by 2.75) μ.
1-septate, 4 per cent, 18 by 3 (17 to 20 by 2.75 to 3.5) μ.
2-septate, 3 per cent, 21 by 3.5 μ.
3-septate, 41 per cent, 30 by 3.75 (22 to 44 by 3.25 to 4.5) μ.
4-septate, 8 per cent, 38 by 4.5 (34 to 45 by 4.5) μ.
5-septate, 34 per cent, 42 by 4.25 (32 to 50 by 3.5 to 5) μ.
6-septate, 4 per cent, 48 by 4.75 (47 to 49 by 4.5 to 5) μ.
7-septate, 2 per cent.
8-septate, 1 per cent, 50 by 5 (50 to 51 by 5 to 5.5) μ.
9-septate, 1 per cent, 53 by 4.75 (51 to 55 by 4.5 to 5) μ.

Oat agar; culture 16 days old; conidia from pionnotes:
Conidia—
3-septate, 13 per cent.
4-septate, 12 per cent.
5-septate, 74 per cent.
6-septate, 1 per cent.

Rice; culture 2 months old; conidia from pionnotes:
Conidia—
1-septate, 2 per cent.
2-septate, 2 per cent.
3-septate, 50 per cent, 36 by 3 (31 to 40 by 2.5 to 3.5) μ.
4-septate, 11 per cent.
5-septate, 35 per cent, 67 by 3.5 (37 to 82 by 3 to 4.5) μ.
6-septate, 57 by 3.75 μ.

Green bean pod; culture 6 days old; conidia from mycelium:
Conidia—
0-septate, 1 per cent, 11 by 3.5 μ.
1-septate, 4 per cent, 17 by 4.5 (14 to 20 by 3.5 to 6) μ.
2-septate, 2 per cent, 19 by 3.5 (19 to 20 by 3.5) μ.
3-septate, 39 per cent, 31 by 4 (24 to 38 by 3.5 to 5.25) μ.
4-septate, 13 per cent, 39 by 5 (32 to 44 by 4 to 6.25) μ.
5-septate, 41 per cent, 44 by 5 (38 to 52 by 3.5 to 6.00) μ.

Green bean pod; culture 14 days old; conidia from mycelium:
Conidia—
0-septate, 1 per cent, 11 by 4.5 μ.
1-septate, 12 per cent, 15 by 2.75 (14 to 18 by 2.75 to 3) μ.
2-septate, 4 per cent, 20 by 3.5 (19 to 29 by 2.75 to 4.5) μ.

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3-septate, 43 per cent, 26 by 3.5 (21 to 34 by 2.75 to 4) μ.
4-septate, 4 per cent, 34 by 4 (32 to 36 by 3.5 to 4.5) μ.
5-septate, 27 per cent, 43 by 4.25 (37 to 48 by 4 to 5) μ.
6-septate, 6 per cent, 49 by 4.75 (49 to 50 by 4.5 to 5) μ.
7-septate, 1 per cent, 48 by 4.75 (46 to 51 by 4.5 to 5) μ.
8-septate, 1 per cent, 57 by 5 (50 to 60 by 4.5 to 5.25) μ.
9-septate.
10-septate, 1 per cent, 59 by 5.25 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 35 per cent, 30 by 3.5 (18 to 44 by 2.5 to 5.25) μ.
4-septate, 11 per cent, 38 by 4.25 (32 to 45 by 3 to 6.25) μ.
5-septate, 45 per cent, 48 by 4.25 (32 to 82 by 3 to 5.25) μ.

VIII. Section LISEOLA Wollenweber, Sherbakoff, Reinking, Johann, and Bailey

Section *Moniliforme* Sherbakoff; subsection *Constrictum* Wollenweber; section *Liseola* WOLLENWEBER, SHERBAKOFF, REINKING, JOHANN, and BAILEY, Journ. Agr. Research 30 (1925) 841.

Microconidia more or less formed in chains, spindle to ovoid in shape; macroconidia slender with a slightly constricted top end, and a pedicellate base, form and color similar to section *Lateritium*, scattered, in sporodochia or in pionnotes, brownish white to orange cinnamon; chlamydospores absent; stroma vinaceous to violet, spread out or erumpent, often with sclerotia. Conidial stage of *Gibberella* section *Lisea* (Saccardo) Wollenweber.

FUSARIUM MONILIFORME Sheldon. Plate 1, fig. 9; text fig. 17.

Fusarium moniliforme SHELDON, 17th Annual Report, Nebraska Agr. Exp. Sta. 1903 (1904) 23–32; SACCARDO, Syll. Fung. 22: 1485; WOLLENWEBER, Ann. Myc. 15 (1917) 23; WOLLENWEBER and REINKING, Phytopath. 15 (1925) 162; WINELAND, GRACE O., Journ. Agr. Research 28 (1924) 909–922 (an ascigerous stage and synonymy for *Fusarium moniliforme*).

Wineland has named this fungus *Gibberella moniliformis* (Sheldon) Wineland and discusses its possible relation to *Gibberella acervalis* (Moug.) Wollenweber.

Microconidia in chains or in false heads formed in white to Isabella color, aërial mycelium, spindle to ovoid in shape, 5 to 12 by 2.25 to 4 μ; macroconidia delicate and slender, sickle-shaped, attenuate, pedicellate, scattered or in sporodochia or pionnotes, brownish white to orange cinnamon; mostly 3–septate, 30 to 36 by 3 to 3.5 (23 to 48 by 2.25 to 4) μ, fewer 1–, 4–, 5–septate; 1–septate, 12 to 18 by 2.25 to 3.5 μ; 4–septate, 37 to 53 by 3 to 3.5 μ; 5-septate, 43 to 66 by 3 to 3.5 μ; chlamydospores absent; sclerotia blue, stroma violet or ochraceous.

Under certain conditions some cultures produce blue to almost black *Gibberella*-like sclerotia up to 0.5 mm.

Habitat.—On diseased kernels of corn (*R 73*), on cut ends of corn stems and cob (*Zea mays* Linnæus); on leaves, in interior of diseased pseudostems, and on dead floral parts (*R 53*) of banana (*Musa sapientium* Linnæus), on decaying undetermined plant, and in soil and air. Tela and Trujillo, Honduras, Central America (*Reinking R 53, R 73*). On rotting bud leaves of pineapple (*Ananas sativus* Schultes). Jamaica (*Hansford 5, R 225*).

Fusarium moniliforme is the cause of a corn-mold disease in the United States and Central America.

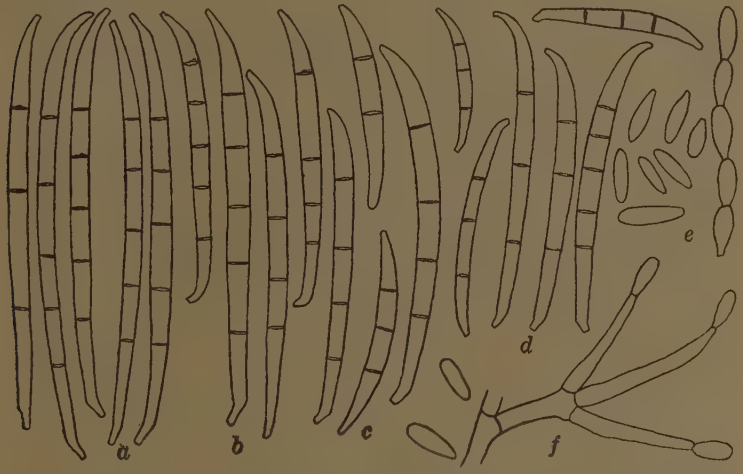

FIG. 17. *Fusarium moniliforme* Sheldon; *a*, conidia from pionnotes of one-month-old rice culture; *b*, conidia from pionnotes of 25-day-old potato-tuber plug culture; *c*, conidia from pionnotes and mycelium of 6-day-old hard potato-agar culture; *d*, conidia from sporodochia of 1-month-old *Melilotus*-stem culture; *e*, microconidia, some in chains, from mycelium of 5-day-old hard potato-agar culture; *f*, conidiophore, portion of, from mycelium of 5-day-old hard potato-agar plate culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a scant, medium coarse, pale pinkish buff and pale pinkish cinnamon mycelium, tufted in places. Dusky bluish green spots are usually present, especially near the base of the slant. Light ochraceous salmon or vinaceous cinnamon pionnotes develop over the slant. Deep slate green *Gibberella*-like sclerotia may develop in certain cultures. Older cultures, up to 3 months of age, have a scant cartridge buff or pale ochraceous buff mycelium

with spots of dusky bluish green here and there. The pionnotal growth over the slant is light buff, pinkish buff, or pinkish cinnamon. Sclerotia if present are black, but blue with transparent light. On potato-agar plates 2 months old a short, twisted, woolly, pale pinkish cinnamon, aërial mycelium is produced. A pale pinkish cinnamon pionnotes usually is present.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have an aërial mycelium that is scant, short, twisted, woolly, and pale grayish vinaceous. The substratum is dark vinaceous brown.

Oat agar.—Cultures 1 month old have a medium dense, thick, matted, white and pinkish cinnamon mycelium. The mycelium may be powdery in places and with spots of nigrosin violet, dark nigrosin violet, and dark bluish gray-green. A pale pinkish cinnamon pionnotes may be present.

Rice.—Cultures 20 days old have a medium dense, thin, matted, thulite pink and spinel red mycelium. At the base it may be leathery and auricula purple and pale salmon color. The rice is turned ochraceous orange, yellow ocher, or mustard yellow. Older cultures, up to 2 months of age, have a medium dense mycelium that is usually pinkish cinnamon, dark maroon-purple, dahlia carmine, and dusky auricula purple. Salmon buff and light ochraceous buff may also occur. The rice is changed to straw yellow or mustard yellow, often with deep slate violet in places. Small, buff pink sclerotia may be present. Spinel red, Indian lake, or cream buff and light pinkish cinnamon pionnotes masses are usually produced.

Potato-tuber plug.—Cultures 21 days old usually have a matted, seashell pink, olive and orange pink with indigo mycelium below. Minute dusky green-blue or deep delft blue sclerotia may be present. Older cultures, from 1 to 2.5 months old, have a rather scant, thin and fluffy, sometimes leathery, aërial mycelium that is seashell pink or light pinkish cinnamon in places, but chiefly dusky slate blue, dusky bluish green, petunia violet, Hortense blue, and deep delft blue. A seashell pink, pinkish buff, vinaceous buff, or light pinkish cinnamon pionnotes is usually present.

Melilotus stem.—Cultures 2 months old are characterized by having a short, scant, woolly and powdery, pale pinkish cinnamon and dusky dull bluish green mycelium over the stem. A light pinkish cinnamon pionnotes is produced.

Mature corn stalk.—Cultures 17 days old have a dense, white mycelium tinged with salmon buff and slight amounts of sea

green. Cultures 1 to 2 months old may have a dense, white and salmon buff mycelial growth.

Banana peel.—Cultures 1 month old have a scant, matted, cartridge buff, cream buff, or pale pinkish buff and cinnamon mycelium. Pale cinnamon pink and light vinaceous cinnamon pionnotes masses or honey yellow, hemispheric sporodochia are usually produced.

Green bean pod.—Cultures 10 days old have a dense, fluffy, white mycelium. Older cultures, up to 3 months of age, are characterized by having a dense, fluffy or thin, matted, pale pinkish cinnamon, light pinkish cinnamon, and pinkish cinnamon mycelium over the bean. Orange cinnamon and Verona brown sporodochia or light pinkish cinnamon pionnotes masses are usually present. Pinkish buff or blackish slate sclerotia may be produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 2 months old; conidia from pionnotes:
Conidia—
0-septate, 42 per cent, 9 by 3 (5 to 14 by 1.75 to 3.5) μ.
1-septate, 6 per cent, 19 by 3.5 (14 to 23 by 2.75 to 3.5) μ.
2-septate, 2 per cent, 22 by 3.25 (21 to 23 by 3 to 3.5) μ.
3-septate, 44 per cent, 33 by 3.25 (23 to 45 by 2.75 to 4) μ.
4-septate, 4 per cent, 43 by 3.5 (37 to 53 by 3.5) μ.
5-septate, 2 per cent, 41 by 4 (41 to 50 by 3 to 3.5) μ.

Rice; culture 21 days old; conidia from pionnotes:
Conidia—
3-septate, 33 per cent.
4-septate, 27 per cent.
5-septate, 40 per cent.

Potato-tuber plug; culture 25 days old; conidia from mycelium and pionnotes:
Conidia—
3-septate, 91 per cent.
4-septate, 8 per cent.
5-septate, 1 per cent.

Melilotus stem; culture 1 month old; conidia from sporodochia:
Conidia—
3-septate, 81 per cent, 38 by 2.75 (23 to 46 by 2.25 to 3) μ.
4-septate, 14 per cent, 46 by 2.75 (42 to 50 by 2.5 to 3) μ.
5-septate, 5 per cent.

Green bean pod; culture 17 days old; conidia from pionnotes:
Conidia—
0-septate, 22 per cent, 7 by 2.75 (5 to 10 by 2.25 to 3.5) μ.
1-septate, 16 per cent, 12 by 3.5 (11 to 13 by 3.25 to 3.5) μ.
2-septate, 4 per cent, 26 by 3.25 (21 to 31 by 3 to 3.5) μ.
3-septate, 56 per cent, 34 by 3.25 (27 to 45 by 2.75 to 3.5) μ.
4-septate, 1 per cent, 42 by 3.25 (37 to 42 by 3.25) μ.
5-septate, 1 per cent, 55 by 3.5 (50 to 63 by 3.5) μ.

Frequently 95 to 100 per cent 0-septate conidia only are produced on the various media.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—

0-septate, 15 per cent, 8 by 3 (5 to 14 by 1.75 to 3.5) μ.
1-septate, 4 per cent, 15 by 3 (12 to 18 by 2.25 to 3.5) μ.
2-septate, 2 per cent, 24 by 3.25 (21 to 31 by 3 to 3.5) μ.
3-septate, 61 per cent, 34 by 3 (23 to 48 by 2.25 to 4) μ.
4-septate, 9 per cent, 43 by 3.5 (37 to 53 by 3 to 3.5) μ.
5-septate, 9 per cent, 47 by 3.5 (43 to 66 by 3 to 3.5) μ.

FUSARIUM MONILIFORME Sheldon var. ERUMPENS Wollenweber and Reinking. Plate 1, fig. 10; text fig. 18.

Fusarium moniliforme erumpens WOLLENWEBER and REINKING, Phytopath. 15 (1925) 163.

Differs from the type by having more and larger, rugose, dark blue sclerotia, erumpent and clustered *Gibberella*-like; microconidia in chains; 0-septate, 5 to 14 by 2 to 3 μ; macroconidia mostly 3- to 5-septate; 3-septate, 22 to 48 by 2.5 to 3.5 μ; 4-septate, 33 to 47 by 3.25 to 3.5 μ; 5-septate, 33 to 51 by 3.25 to 3.5 μ; chlamydospores absent.

Habitat.—In vascular bundles of living, diseased pseudostem of banana (*Musa sapientium* Linnæus). Tela, Honduras, Central America (*Reinking R 62*).

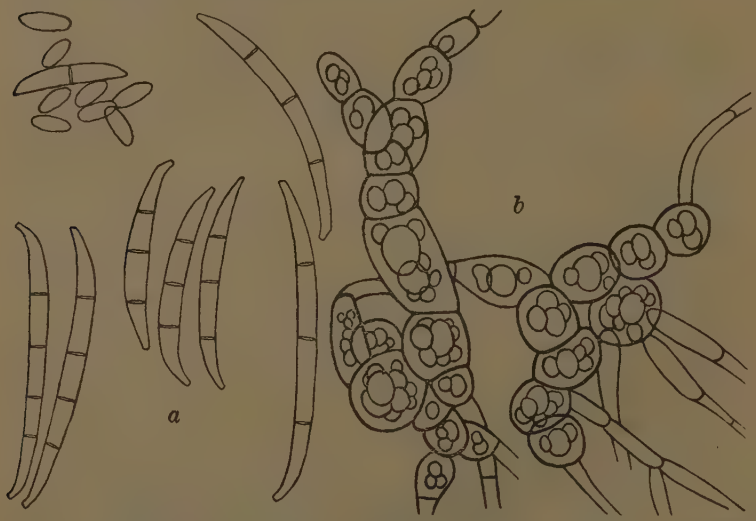

FIG. 18. *Fusarium moniliforme* Sheldon var. *erumpens* Wollenweber and Reinking; *a*, conidia from mycelium of 22-day-old hard potato-agar culture; *b*, early formation of sclerotial plectenchymica from mycelium in 14-day-old water culture.

Soil inoculations about banana plants failed to produce infection.(7)

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 5 days old have a medium scant, matted, pale pinkish buff mycelium with a cinnamon buff pionnotes. Older cultures, up to 3 months old, have a cartridge buff and light buff mycelium with spots of bluish slate black. A light buff and light vinaceous cinnamon pionnotes is produced. Potato-agar plates 2 months old have a short, twisted, woolly, aërial mycelium that is pale pinkish buff. A pionnotes of the same color is produced.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a scant tufted aërial mycelium that is pale grayish vinaceous and delft blue, slate violet(1) stromatic bodies are formed. The mycelium in the substratum is burnt lake.

Oat agar.—Cultures 1 month old are characterized by a thick, dense, matted, felty, twisted, white and pale pinkish buff mycelium, woolly in places. Stromatic masses just over agar may be blue-violet-black. An abundance of blue-violet-black sclerotia, 0.5 to 1 mm in diameter, are formed over the base of the slant.

Rice.—Cultures 21 days old have a medium dense, matted, rosolane purple, Schoenfeld's purple, and auricula purple mycelium. It may also be thulite pink in places over the rice. The rice is colored cameo. Older cultures, up to 2 months old, have a matted mycelium above and leathery below that is cameo pink to dark maroon-purple on top with pale cinnamon pink and light vinaceous cinnamon below. The rice is changed to shrimp pink.

Potato-tuber plug.—Cultures 25 days old have a matted, pale pinkish buff and dark delft blue mycelium. Dark bluish gray-green and dusky dull bluish green sclerotia are produced over the potato. Light pinkish cinnamon sporodochia and pionnotes masses are found in places. Older cultures, up to 80 days of age, have a more or less leathery, dusky slate blue mycelium, with dusky slate sclerotia and a tilleul buff pionnotes.

Melilotus stem.—Cultures 2 months old have a medium scant, tufted, and matted mycelium over the stem that is pale pinkish cinnamon with the stromatic masses dusky dull bluish green. Dark delft blue sclerotial masses, 0.5 to 3 mm in diameter, are formed all over the stem. Cinnamon sporodochia may be present.

Alnus stem.—Cultures 1 month old have a scant, aërial, pale vinaceous violet and deep purplish vinaceous mycelium. Sporodochia are produced here and there and are pale pinkish buff.

Banana peel.—Cultures 26 days old have a scant white and pale purplish vinaceous mycelium. Black sclerotia in wart-like heaps are present. Cinnamon and dark grayish olive sporodochia are produced.

Green bean pod.—Cultures 2 to 3 months old have a thin, matted, cartridge buff, cream buff, and cinnamon buff mycelium. A cinnamon buff or tawny olive pionnotes is produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 1 month old; conidia from pionnotes:
Conidia—
0-septate, 22 per cent, 9 by 2.5 (5 to 14 by 2 to 2.75) μ.
1-septate, 9 per cent, 13 by 2.75 (12 to 15 by 2.75) μ.
2-septate, 3 per cent, 19 by 3 (19 to 20 by 2.75 to 3.25) μ.
3-septate, 36 per cent, 33 by 3 (22 to 48 by 2.5 to 3.5) μ.
4-septate, 12 per cent, 37 by 3.5 (33 to 42 by 3.5) μ.
5-septate, 18 per cent, 38 by 3.5 (33 to 43 by 3.5) μ.
Green bean pod; culture 25 days old; conidia from pionnotes:
Conidia—
0-septate, 32 per cent, 7 by 2.75 (5 to 10 by 2.25 to 3) μ.
1-septate, 9 per cent, 15 by 3 (15 to 16 by 2.75 to 3.5) μ.
2-septate, 2 per cent, 18 by 3 (17 to 20 by 2.75 to 3.25) μ.
3-septate, 38 per cent, 31 by 3 (22 to 40 by 2.75 to 3.25) μ.
4-septate, 9 per cent, 41 by 3.25 (36 to 47 by 3.25 to 3.5) μ.
5-septate, 10 per cent, 45 by 3.5 (41 to 51 by 3.25 to 3.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—
3-septate, 37 per cent, 32 by 3 (22 to 48 by 2.5 to 3.5) μ.
4-septate, 10 per cent, 38 by 3.25 (33 to 47 by 3.25 to 3.5) μ.
5-septate, 14 per cent, 41 by 3.5 (33 to 51 by 3.25 to 3.5) μ.

FUSARIUM MONILIFORME Sheldon var. SUBGLUTINANS Wollenweber and Reinking. Text fig. 19.

Fusarium moniliforme subglutinans WOLLENWEBER and REINKING, Phytopath. 15 (1925) 163.

Differs from the type principally in having the microconidia not borne in chains; microconidia unicellular, 6 to 15 by 2 to 3.5 μ; macroconidia mostly 3-septate, 25 to 38 by 2.75 to 3.5 (18 to 50 by 2.75 to 4) μ; fewer 1-septate, 10 to 25 by 2.5 to 3.5 μ; 4-septate, 27 to 50 by 3.25 to 4 μ; sometimes 5-septate, 43 to 55 by 3.25 to 4 μ; 6- to 7-septate, 48 to 57 by 3.25 to 4 μ; chlamydospores absent; sclerotia dark blue.

Habitat.—On decaying leaves and pseudostem, in the vascular bundles and exterior of living pseudostem of banana (*Musa sapientium* Linnæus) and in the air. Tela and Trujillo, Honduras, Central America (*Reinking R 60*).

Soil inoculations about banana plants failed to produce infection.(7)

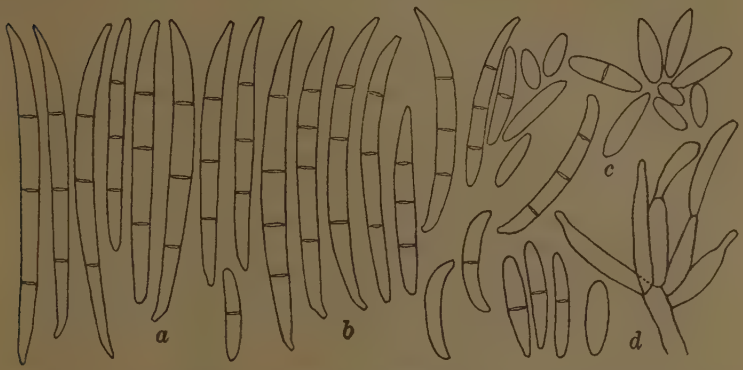

FIG. 19. *Fusarium moniliforme* Sheldon var. *subglutinans* Wollenweber and Reinking; *a*, conidia from pionnotes of 17-day-old hard potato-agar culture; *b*, conidia from sporodochia of 1-month-old *Melilotus*-stem culture; *c*, microconidia from mycelium of 16-day-old hard potato-agar culture; *d*, conidiophore, portion of, from mycelium of 20-day-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—On 2 to 14-day-old cultures a medium scant, cartridge buff, shell pink, vinaceous pink, and sometimes rosolane purple mycelium is produced. A tawny olive and Saccardo's umber coloration may also be present. A salmon buff pionnotes is formed. Older cultures, up to 3 months old, have a matted, dense, and felty, shell pink, rosolane purple, light pinkish cinnamon growth at the top of the slant, and at the base a growth that is Corinthian red, cinnamon brown, slate purple, and dusky green-blue.(2) The pionnotes is light vinaceous cinnamon or pale ochraceous buff. On potato-agar plates, 2 months old, a short, woolly, and powdery, pale pinkish cinnamon mycelium is produced over the plate.

Potato-agar plate, 5 per cent dextrose.—One-month-old cultures have a scant, pale grayish vinaceous aërial mycelium. The mycelium in the substratum is a burnt lake.

Oat agar.—Cultures 1 month old are characterized by a medium dense, twisted, woolly, pale pinkish cinnamon with deep

slate blue and dusky slate blue mycelium. Spots of dusky slate violet, bluish slate black, deep hyssop violet, and light vinaceous cinnamon may be present in places.

Rice.—Cultures 21 days old have a medium dense and matted, spinel red, rosolane purple, and Schoenfeld's purple mycelium. The rice is turned shrimp pink or neutral red. Older cultures, up to 2 months of age, have a thin, matted, thulite pink, spinel pink, dark maroon-purple, salmon buff, and salmon mycelium over the rice, leathery in places. Spots of yellow ocher may be present. Salmon and light vinaceous cinnamon pionnotes masses are produced. Deep delft blue or blackish brown,(1) small sclerotia may be present. The rice in older cultures is straw yellow and amber yellow. The addition of a 10 per cent solution of potassium hydroxide to a young culture turns the mycelium and substratum dusky auricula purple.

Potato-tuber plug.—Cultures 19 to 30 days old have a scant to dense, matted mycelium that is seashell pink, pale pinkish buff, pale pinkish cinnamon, cameo pink, light mauve, and deep delft blue. Minute deep delft blue sclerotia may be present. Pinkish cinnamon and light vinaceous cinnamon pionnotes masses are formed. Cultures up to 80 days of age have a dense, matted, sometimes leathery, pinkish buff, dusky green-blue,(1) nigrosin violet, dark chessylite blue, and dark bluish gray-green mycelium. Deep delft blue sclerotia may be present. The pionnotes is light ochraceous buff, light pinkish cinnamon, or dark bluish gray-green.

Melilotus stem.—Cultures 2 months old have a thick, dense, matted, aërial mycelium that is pale cinnamon pink. In places the stem is covered with dusky dull bluish green stromatic masses.

Banana peel.—Cultures 26 days old have a medium dense and matted white and pale pinkish buff mycelium. A vinaceous cinnamon pionnotes may be produced. Older cultures have the same appearance.

Banana-fruit flesh.—Cultures 26 days old have a medium dense and matted, deep slate violet and dark livid purple mycelium.

Green bean pod.—Cultures 1 to 2 months old have a thin to dense, matted mycelium that is cartridge buff, pinkish buff, pale pinkish cinnamon, cinnamon buff, and sometimes deep olive buff. A light pinkish cinnamon, light vinaceous cinnamon, or dark olive buff pionnotes is produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 11 days old; conidia from pionnotes:
Conidia—
0-septate, 19 per cent, 11 by 2 (9 to 14 by 1.75 to 2.25) μ.
1-septate, 65 per cent, 17 by 2.5 (10 to 25 by 2.25 to 3.25) μ.
2-septate, 5 per cent, 21 by 2.75 μ.
3-septate, 11 per cent, 33 by 3.5 (22 to 32 by 3.75 to 4.5) μ.
4-septate, rare.
5-septate, rare, 43 by 4.5 μ.
6-septate, rare.
7-septate, rare, 48 by 4.5 μ.

Hard potato agar; culture 30 days old; conidia from pionnotes:
Conidia—
0-septate, 10 per cent, 12 by 3.5 (11 to 15 by 2.75 to 3.5) μ.
1-septate, 21 per cent, 18 by 3 (16 to 20 by 2.75 to 3.5) μ.
2-septate, 12 per cent, 22 by 3.5 (21 to 23 by 3.5) μ.
3-septate, 52 per cent, 33 by 3.5 (24 to 48 by 3.24 to 4) μ.
4-septate, 3 per cent, 39 by 3.5 (37 to 41 by 3.5) μ.
5-septate, 2 per cent, 47 by 3.25 μ.

Hard potato agar; culture 44 days old; conidia from pionnotes:
Conidia—
0-septate, 18 per cent, 10 by 3 (6 to 15 by 2.75 to 3.5) μ.
1-septate, 20 per cent, 16 by 3 (10 to 20 by 2.75 to 3.25) μ.
2-septate, 3 per cent, 19 by 3 (16 to 22 by 2.75 to 3.25) μ.
3-septate, 47 per cent, 38 by 3.5 (23 to 30 by 2.75 to 4) μ.
4-septate, 4 per cent, 48 by 3.75 (46 to 50 by 3.25 to 4) μ.
5-septate, 7 per cent, 53 by 3.75 (51 to 53 by 3.5 to 4) μ.
6-septate, 1 per cent, 51 by 3.75 (48 to 57 by 3.25 to 4) μ.

Melilotus stem; culture 1 month old; conidia from pionnotes:
Conidia—
0-septate, 10 per cent.
1-septate, 35 per cent.
2-septate, 16 per cent.
3-septate, 32 per cent, 35 by 2.75 (30 to 41 by 2.75 to 3) μ.
4-septate, 3 per cent.
5-septate, 4 per cent.

Green bean pod; culture 10 days old; conidia from pionnotes:
Conidia—
0-septate, 61 per cent, 10 by 2.5 (8 to 14 by 2.25 to 2.75) μ.
1-septate, 17 per cent, 19 by 3 (15 to 22 by 2.75 to 3.25) μ.
2-septate, 6 per cent, 21 by 3.5 (20 to 23 by 3.25 to 3.5) μ.
3-septate, 15 per cent, 25 by 3.5 (18 to 36 by 3.25 to 3.5) μ.
4-septate, 1 per cent, 27 by 3.5 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 31 per cent, 32 by 3.5 (18 to 50 by 2.75 to 4) μ.
4-septate, 2 per cent, 38 by 3.5 (27 to 50 by 3.25 to 4) μ.
5-septate, 2 per cent, 50 by 3.5 (43 to 55 by 3.25 to 4) μ.

FUSARIUM MONILIFORME Sheldon var. **MAIUS** Wollenweber and Reinking. Plate 1, fig. 11; Plate 6; text fig. 20.

Fusarium moniliforme maius WOLLENWEBER and REINKING, Phytopath. 15 (1925) 163.

Differs from the type by longer macroconidia, 3- to 5- (6-) septate; 3-septate, 28 to 48 by 2.25 to 3.5 μ; 4-septate, 44 to 64 by 2.25 to 3.25 μ; 5-septate, 54 to 76 by 2.5 to 3.25 μ; 6-septate, 61 to 92 by 2.5 to 3.25 μ; microconidia in chains, unicellular, 4 to 16 by 2 to 4 μ; rarely 1-septate, 14 to 21 by 2.5 to 3.5 μ; chlamydospores absent; sclerotia dark blue.

Habitat.—On dead peduncle and leaves of banana (*Musa sapientium* Linnæus). Tela, Honduras, Central America (*Reinking R 57*).

GROWTH ON VARIOUS MEDIA

The growth and color characters on the various media are similar to those of *F. moniliforme.*

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 16 days old; conidia from pionnotes:
Conidia—
0-septate, 35 per cent, 8 by 2.75 (5 to 12 by 1.75 to 4.5) μ.
1-septate, 3 per cent, 16 by 3 (12 to 23 by 2.75 to 3.5) μ.
2-septate.
3-septate, 12 per cent, 42 by 3 (37 to 48 by 2.75 to 3.5) μ.
4-septate, 16 per cent, 46 by 2.75 (44 to 49 by 2.75) μ.
5-septate, 29 per cent, 57 by 2.75 (54 to 61 by 2.75 to 3.25) μ.
6-septate, 5 per cent, 64 by 2.75 (61 to 66 by 2.75) μ.

Hard potato agar; culture 70 days old; conidia from pionnotes:
Conidia—
0-septate, 65 per cent, 8 by 2.5 (4 to 20 by 2.25 to 4.5) μ.
1-septate, 4 per cent, 13 by 3 (10 to 17 by 2.75 to 3.5) μ.
2-septate.
3-septate, 13 per cent, 35 by 3.25 (21 to 39 by 3.25) μ.
4-septate, 13 per cent.
5-septate, 5 per cent.

Melilotus stem; culture 18 days old; conidia from sporodochia:
Conidia—
0-septate, 3 per cent, 10 by 2.75 (6 to 15 by 2 to 3.5) μ.
1-septate, 2 per cent, 19 by 3 (13 to 25 by 2.5 to 3.75) μ.
2-septate.
3-septate, 79 per cent, 39 by 2.75 (25 to 54 by 2.25 to 3) μ.
4-septate, 12 per cent, 62 by 2.75 (60 to 64 by 2.5 to 3) μ.
5-septate, 2 per cent, 69 by 2.75 (62 to 76 by 2.5 to 3.25) μ.
6- to 7-septate, 2 per cent, 79 by 2.75 (67 to 92 by 2.5 to 3.25) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

0-septate, 34 per cent, 9 by 2.75 (4 to 16 by 2 to 4) μ.
1-septate, 3 per cent, 16 by 3 (14 to 21 by 2.5 to 3.5) μ.
3-septate, 35 per cent, 39 by 3 (28 to 48 by 2.25 to 3.5) μ.
4-septate, 14 per cent, 54 by 2.75 (44 to 64 by 2.25 to 3.25) μ.
5-septate, 12 per cent, 63 by 2.75 (54 to 76 by 2.5 to 3.25) μ.
6-septate, 2 per cent, 71 by 2.75 (61 to 92 by 2.5 to 3.25) μ.

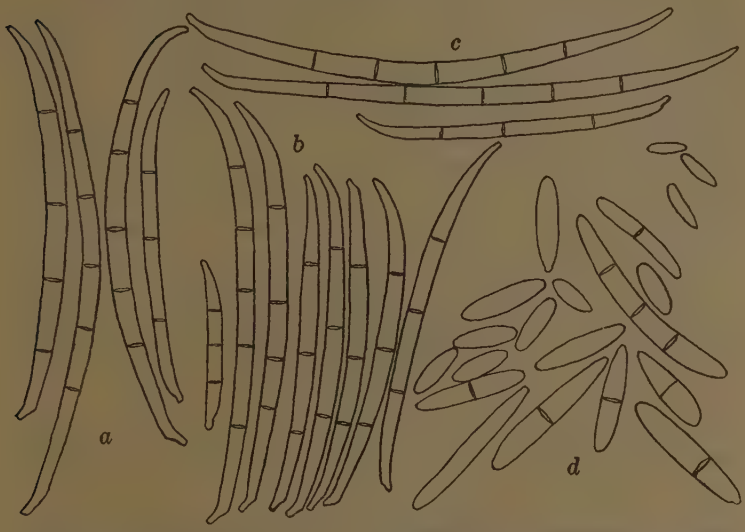

FIG. 20. *Fusarium moniliforme* Sheldon var. *maius* Wollenweber and Reinking; *a*, conidia, long, typical type, from pionnotes of 11-day-old hard potato-agar culture; *b*, conidia from sporodochia of 16-day-old *Melilotus*-stem culture; *c*, conidia from pionnotes of 11-day-old hard potato-agar culture; *d*, microconidia from pionnotes and mycelium of 11-day-old hard potato-agar culture.

FUSARIUM NEOCERAS Wollenweber and Reinking. Text fig. 21.

Fusarium neoceras WOLLENWEBER and REINKING, Phytopath. 15 (1925) 164.

Microconidia scattered or in false heads, not in chains, unicellular, ovoid fusoid, 9 to 12 by 3 to 3.5 (5 to 18 by 2.75 to 4.5) μ; rarely 1-septate, 19 to 26 by 3.5 to 4.5 (14 to 34 by 3.25 to 5.5) μ; macroconidia in sporodochia, but mostly in pionnotes, elongate, slightly curved, attenuate, subpedicellate, slightly constricted at the top, 3- to 5-septate, 38 to 68 by 4 to 5 (30 to 95 by 3.5 to 5.5) μ; 3-septate, 32 to 59 by 3 to 5.5 μ; 4-septate, 30 to 63 by 4 to 5.5 μ; 5-septate, 55 to 67 by 4.5 to 5.5 μ;

very seldom 6- to 9-septate, 51 to 120 by 4 to 5 μ; chlamydospores and sclerotia absent; stroma sometimes violet.

Habitat.—On dead floral bracts of banana (*Musa sapientium* Linnæus) (*R 149*) and in the soil. Tela, Honduras, Central America (*Reinking R 149*).

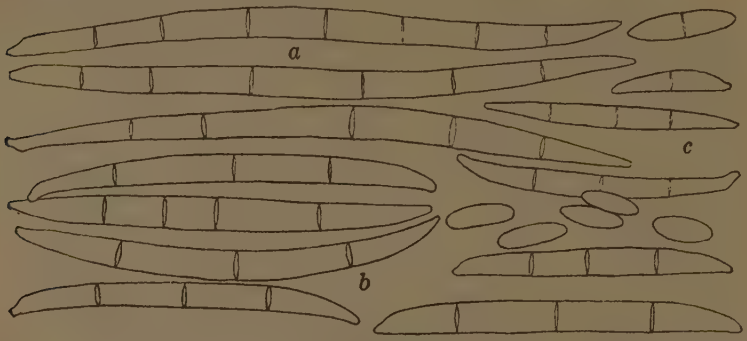

FIG. 21. *Fusarium neoceras* Wollenweber and Reinking; *a*, conidia from mycelium of 6-day-old hard potato-agar culture; *b*, conidia from mycelium of 20-day-old potato-tuber plug culture; *c*, macroconidia and microconidia from thin pionnotes of 37-day-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 4 to 12 days old have a dense mycelium with coarse mycelial strands standing out from the mass. The aërial mycelium is white and ivory yellow and pinkish buff with a stroma over the agar that is blackish violet. Dark hyssop violet concentric rings may appear at first on the agar about the point of transfer. Older cultures, up to 3.5 months old, have a dense aërial mycelium, with coarse mycelial strands, that is cartridge buff with deep slate brown concentric rings in agar or a blackish violet stroma. A cream buff pionnotes is usually produced. On potato agar plates 2 months old a medium scant, zonate, pale pinkish buff, aërial mycelium is present. Concentric rings of pale pinkish buff and hyssop violet are usually present.

Oat agar.—Cultures 24 days old are characterized by having a dense, thick, and matted mycelium that is white at the tips, but chiefly petunia violet and nigrosin violet.

Rice.—Cultures 21 days old have a dense, matted mycelium that is dull dark purple, dull dusky purple, with spinel red and Indian lake in the center and auricula purple and dusky auricula

purple at the base. Two-month-old cultures are matted and leathery with dark nigrosin violet at the top, and lower down dahlia carmine, dark maroon-purple, and dark perilla purple.

Potato-tuber plug.—Cultures 25 days old have a dense, matted, white, petunia violet, dark violet, raisin purple, and deep delft blue mycelium. Older cultures, 80 days old, have a thin matted and leathery mycelium that is dusky dull bluish green, dark delft blue, blackish violet, and blue-violet-black. A vinaceous buff and deep olive buff pionnotes is developed.

Melilotus stem.—Cultures 2 months old are characterized by a thick, dense, matted, pale pinkish buff, yellow ocher, and Dresden brown mycelial mass.

Mature corn stalk.—Cultures 1 month old have a medium dense and fluffy mycelium that is petunia violet, Bradley's violet, and dark vinaceous.

Banana peel.—Cultures 26 days old have a scant Mathews' purple mycelium.

Green bean pod.—Cultures 30 to 45 days old have a medium scant, cottony to leathery, cartridge buff, pale pinkish buff, petunia violet, and nigrosin violet mycelium. A cream buff and later dark olive buff pionnotes is produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; cultures 6 days old; conidia from mycelium and pionnotes:

Conidia—

0-septate, 12 per cent, 12 by 2.75 (7 to 16 by 2.75 to 3) μ.
1-septate, 6 per cent.
2-septate.
3-septate, 48 per cent, 46 by 3.5 (37 to 54 by 3 to 4) μ.
4-septate, 12 per cent, 59 by 4.5 (51 to 63 by 4.25 to 5) μ.
5-septate, 20 per cent, 63 by 3.75 (60 to 67 by 3.25 to 4) μ.
6-septate, 1 per cent.
7-septate.
8-septate.
9-septate, 1 per cent, 94 by 4.5 (67 to 120 by 4 to 5) μ.

Hard potato agar; culture 11 days old; conidia from pionnotes:

Conidia—

0-septate, 10 per cent, 11 by 2.75 (9 to 14 by 2.75 to 3.25) μ.
1-septate, 28 per cent, 24 by 3.5 (23 to 26 by 3.25 to 3.5) μ.
2-septate.
3-septate, 56 per cent, 53 by 4.75 (34 to 59 by 3.5 to 5.5) μ.
4-septate, 4 per cent, 58 by 4.75 (54 to 63 by 4.5 to 5.5) μ.
5-septate, 2 per cent, 61 by 5 (55 to 67 by 4.5 to 5.5) μ.

Hard potato agar; culture 18 days old; conidia from mycelium and pionnotes:

Conidia—

0-septate, 57 per cent, 12 by 3.5 (6 to 18 by 2.75 to 4.5) μ.
1-septate, 11 per cent, 21 by 4 (14 to 26 by 3.25 to 5.5) μ.
2-septate, 2 per cent, 36 by 5 μ.
3-septate, 29 per cent, 44 by 4.5 (34 to 54 by 4 to 5) μ.
4 septate, 1 per cent, 61 by 4.5 μ.

Green bean pod; culture 10 days old; conidia from pionnotes:

Conidia—

0-septate, 37 per cent, 12 by 3 (10 to 16 by 2.75 to 3.25) μ.
1-septate, 19 per cent, 19 by 3.5 (15 to 21 by 3.25 to 4) μ.
2-septate, 3 per cent, 27 by 3.5 (23 to 32 by 3.25 to 4) μ.
3-septate, 28 per cent, 38 by 4 (32 to 46 by 3.5 to 4.5) μ.
4-septate, 13 per cent, 46 by 4 (30 to 57 by 3.5 to 4.5) μ.

Green bean pod; culture 16 days old; conidia from mycelium and pionnotes:

Conidia—

0-septate, 38 per cent, 9 by 3 (6 to 12 by 2.75 to 3.25) μ.
1-septate, 13 per cent, 26 by 4.5 (18 to 34 by 4.5 to 5) μ.
2-septate, 4 per cent, 32 by 5 (29 to 36 by 5) μ.
3-septate, 45 per cent, 48 by 4.75 (36 to 59 by 4.5 to 5.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

0-septate, 31 per cent, 11 by 3 (5 to 18 by 2.75 to 4.5) μ.
1-septate, 14 per cent, 23 by 3.75 (14 to 34 by 3.25 to 5.5) μ.
2-septate, 2 per cent, 31 by 4.25 (23 to 36 by 3.25 to 5) μ.
3-septate, 41 per cent, 46 by 4.25 (32 to 59 by 3.5 to 5) μ.
4-septate, 6 per cent, 56 by 4.5 (30 to 63 by 4 to 5.5) μ.
5-septate, 4 per cent, 62 by 4.25 (55 to 67 by 4.5 to 5.5) μ.
6- to 9-septate, 2 per cent, 94 by 4.5 (67 to 120 by 4 to 5) μ.

The various strains of *Liseola* herein described are widespread throughout banana plantations, being present on decaying plant trash of different kinds and on living parts of plants. The parasitic nature of the different strains has not been carefully tested.(7)

IX. Section LATERITIUM Wollenweber

Lateritium WOLLENWEBER, Ann. Myc. 15 (1917) 54.

Mycelium white, rosy, yellow, sometimes carmine, aërial or immersed; chlamydospores frequently intercalary, but terminal always lacking; sclerotia knotty rugulose, sometimes dark blue; stroma spread out, erumpent; conidia spindle- to sickle-shaped, dorsiventral difference in curvature more conspicuous toward the apex, constricted at both ends or even pedicellate at the base, resembling the section *Elegans*, in tuberculate sporodochia often in long columns protruded, in pionnotes or scattered in

aërial mycelium. Imperfect stage of a *Gibberella*. Color type similar to that for the section *Elegans*, and sometimes to that for *Discolor*.

FUSARIUM FRUCTIGENUM Fries var. MAIUS Wollenweber forma 1 Wollenweber and Reinking. Plate 2, fig. 1; text fig. 22.

Fusarium fructigenum maius forma 1 WOLLENWEBER and REINKING, Phytopath. 15 (1925) 165.

Conidia in sporodochia and pionnotes, orange, spindle- to sickle-shaped, dorsiventral difference in curvature more conspicuous toward the top cell than in the middle, constricted at both ends or even pedicellate at the base, 5- (3- to 6-) septate;

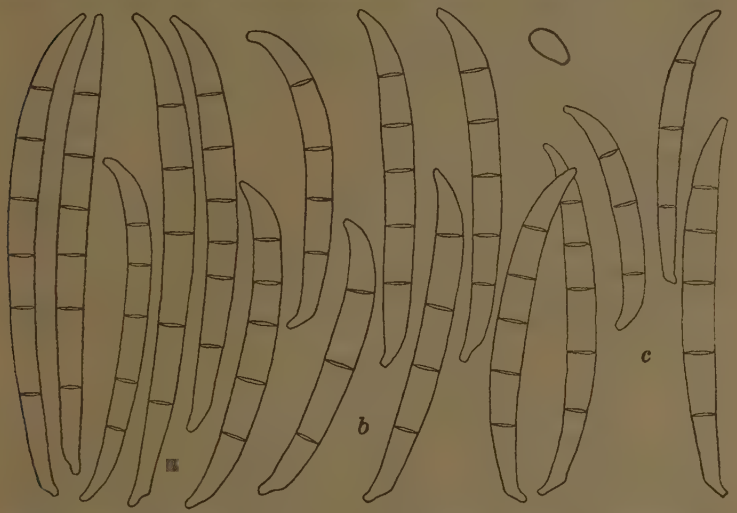

FIG. 22. *Fusarium fructigenum* Fries var. *maius* Wollenweber forma 1 Wollenweber and Reinking; *a*, conidia from pionnotes of 1-month-old rice culture; *b*, conidia from pionnotes of 17-day-old oatmeal-agar culture; *c*, conidia from sporodochia of 14-day old *Melilotus*-stem culture.

5-septate, 48 to 64 by 3.5 to 4.5 μ; 6-septate, 63 to 80 by 3.5 to 4.75 μ; 3-septate, 34 to 44 by 3.5 to 4.5 μ; chlamydospores seldom present; sclerotia 1.5 mm in diameter, dark blue or ochraceous white; stroma carmine, differs from the type by the carmine color of the stroma.

Habitat.—On undetermined dead plant. Jamaica (*Hansford 16, R 235*).

The fungus was not isolated by Reinking, but was obtained through the courtesy of Mr. C. G. Hansford, of Jamaica.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Three-month-old cultures have a scant, white, aërial mycelium. A thick, pale pinkish buff and pinkish buff pionnotal growth is produced over the slant.

Oat agar.—Cultures 1 month old are characterized by a scant, white, aërial mycelium. A pionnotes, made up of small sporodochia, is produced over the slant. The sporodochia may be in concentric rings and vinaceous tawny. The stroma and agar at the base of the slant usually Indian red and Prussian red in places.

Rice.—Cultures 23 days old are medium scant, pale vinaceous pink on top, and on sides have a dark vinaceous mycelium. An apricot buff pionnotes is produced over the rice.

Potato-tuber plug.—Cultures 2 months old have a thin, matted, pale pinkish buff and pinkish buff mycelium over the plug. Small pale pinkish buff, pinkish buff, and dusky dull bluish green sclerotia are produced in places. A pinkish cinnamon pionnotes may be present.

Melilotus stem.—Cultures 1 month old have a scant, pinkish buff mycelium on top of the stem and vinaceous cinnamon sporodochia and pionnotes masses over the sides.

Alnus stem.—Cultures 1 month old are characterized by a scant, pinkish buff mycelium on top of the stem and small light pinkish cinnamon sporodochia scattered over the sides.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Oat agar; culture 12 days old; conidia from pionnotes:
Conidia—
3-septate, 8 per cent, 39 by 4.25 (34 to 44 by 4 to 4.5) μ.
4-septate, 24 per cent, 49 by 4.25 (46 to 52 by 4 to 4.5) μ.
5-septate, 68 per cent, 51 by 4.5 (47 to 54 by 4 to 5) μ.

Melilotus stem; culture 15 days old; conidia from sporodochia and pionnotes:
Conidia—
3-septate, 9 per cent, 43 by 3.75 (42 to 44 by 3.75 to 4) μ.
4-septate, 27 per cent, 58 by 4 (46 to 59 by 4 to 4.25) μ.
5-septate, 64 per cent, 58 by 4.25 (50 to 65 by 3.5 to 4.5) μ.

Rice; culture 1 month old; conidia from pionnotes:
Conidia—
3-septate, 6 per cent, 41 by 4 (38 to 44 by 3.5 to 4.5) μ.
4-septate, 14 per cent, 51 by 4.25 (46 to 55 by 4 to 4.5) μ.
5-septate, 71 per cent, 63 by 4.25 (50 to 75 by 4 to 4.5) μ.
6-septate, 9 per cent, 72 by 4 (63 to 80 by 3.5 to 4.75) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

3-septate, 8 per cent, 41 by 4 (34 to 44 by 3.5 to 4.5) μ.
4-septate, 22 per cent, 53 by 4.25 (46 to 59 by 4 to 4.5) μ.
5-septate, 67 per cent, 56 by 4 (48 to 64 by 3.5 to 4.5) μ.
6-septate, 3 per cent, 72 by 4 (63 to 80 by 3.5 to 4.75) μ.

XI. Section SPICARIOIDES (Wollenweber subsection) Wollenweber, Sherbakoff, Reinking, Johann, and Bailey

Spicarioides WOLLENWEBER, Ber. der Deutsch. Bot. Gesell. 35 (1918) 741; WOLLENWEBER, SHERBAKOFF, REINKING, JOHANN, and BAILEY, Journ. Agr. Research 30 (1925) 841.

Stroma spread out, closely matted, carmine and pale pinkish cinnamon, aërial mycelium, floccose, from white to rose color; macroconidia resembling those in the section *Discolor* in sporodochia and pionnotes, ochraceous, elongate, pluriseptate, pedicellate, constricted at top end; microconidia in *Spicaria*-like chains; chlamydospores absent. Color type, yellow ocher and cinnamon brown.

FUSARIUM DECEMCELLULARE Brick. Plate 2, fig. 2; text fig. 23.

Fusarium decemcellulare BRICK, Jahresber. Ver. f. Angew. Bot. (1908) 237; WOLLENWEBER, Ann. Myc. 15 (1917) 22; Ber. der Deutsch. Bot. Gesell. 35 (1918) 741.

The perfect stage of *F. decemcellulare* Brick, the only species known in this section, has been proved to be *Calonectria rigidiuscula* (Berkeley and Broome) Saccardo. (See Plate 5, figs. 1 to 4.)

Stroma spread out, closely matted, carmine and pale pinkish cinnamon, stroma sometimes erumpent, tubercularialike; aërial mycelium, floccose, from white to rose color; macroconidia in sporodochia, sometimes in columns, and pionnotes, ochraceous, elongate, pedicellate, constricted at top end, 6- to 9-septate, 56 to 94 by 5.5 to 8 μ, fewer 1-, 2-, 3-, 4-, 5-septate; 6-septate, 56 to 73 by 5.5 to 7.25 μ; 7-septate, 60 to 83 by 5.5 to 7.25 μ; 8-septate, 59 to 86 by 6.25 to 7.25 μ; 9-septate (sometimes 75 per cent), 75 to 95 by 6.25 to 8 μ; microconidia in *Spicaria*-like chains, unicellular 5 to 9 by 2.75 to 4.5 μ; 1-septate, 12 to 17 by 4 to 4.5 μ; chlamydospores absent.

Habitat.—On cacao twigs (*Theobroma cacao* Linnæus) affected with die-back. Panama (*Dunlap 161, R 118*).

The fungus was not isolated by Reinking, but was obtained from Dr. V. C. Dunlap, of Panama. Petch[7] regards *Spicaria*

[7] Ann. Roy. Bot. Gard. Peradeniya 6 (1916) 172; 7 (1920) 116.

colorans as the conidial stage of *Calonectria rigidiuscula* (Berkeley and Broome) Saccardo. Weese [8] supports this opinion and has thrown further light upon the synonymy of this ascomycete. The conidial form is so characteristic that there cannot be any doubt in regarding it as identical with the *Calonectria*, if such conidia develop from spore cultures. This has been done by spores taken from perithecia occurring on dead branches of an unknown tree from Los Baños, Laguna Province, Phil-

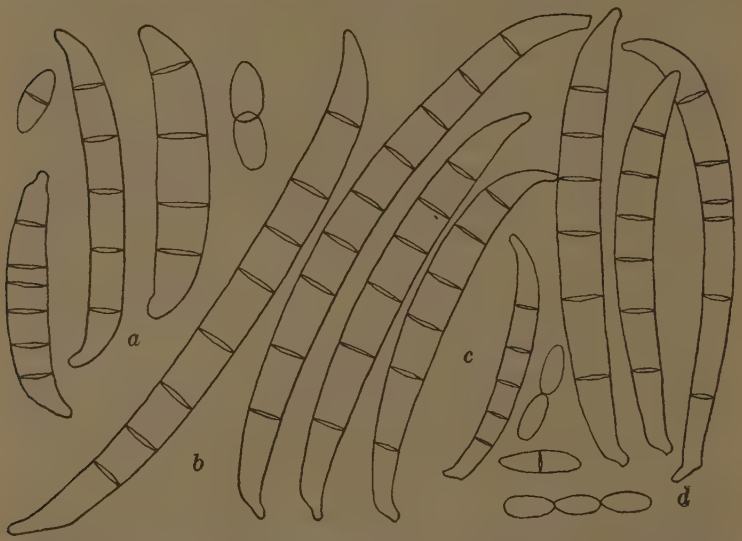

FIG. 23. *Fusarium decemcellulare* Brick; *a*, conidia, not typical and somewhat swollen, from pionnotes of 1-month-old green bean-pod culture; *b*, conidia, typical, from pionnotes of 4-day-old hard potato-agar culture; *c*, conidia, from sporodochia of 2-month-old hard potato-agar culture; *d*, microconidia, in chains, from mycelium of 2-month-old hard potato-agar plate culture.

ippine Islands. The material was sent by Julian Agati on the request of Reinking in 1925 and studied in Berlin by Wollenweber who, in reverse, succeeded in obtaining the perfect stage, not only in pure cultures of this strain, but from another one, collected and isolated from *Hibiscus sabdariffa* Linnæus by M. B. Schwarz, Buitenzorg, Java, and sent for determination in its *Fusarium* stage. These facts are regarded as sufficient proofs for the supposed identity, even if our strain from *Theobroma cacao* Linnæus, fully described in this paper, so far

[8] Beitrag zur Kenntnis der Gattung Calonectria, Mitt. d. bot. Labor. d. Techn. Hochschule, Wien, Heft 2 (1924) 52–56.

has refused to produce perithecia. The synonymy of this fungus is as follows:

Calonectria rigidiuscula (Berkeley and Broome) Saccardo (1878) synonym *Calonectria sulcata* Starback (1899).
Calonectria meliae A. Zimmermann (1901).
Calonectria hibiscicola P. Hennings (1908).
Calonectria squamulosa Rehm (1913).
Calonectria tetraspora (Seaver) Saccardo (1913).
Scoleconectria tetraspora Seaver (1910).
Fusarium decemcellulare Brick (1908).
Spicaria colorans van Hall-de Jonge (1909).
Fusarium spicariae colorantis (van Hall-de Jonge) Saccardo and Trott. (1913).

Distribution on *Anona, Ficus pseudopalma, Hibiscus sabdariffa* and *schizopetalus, Melia azedarach, Theobroma cacao,* and other plants in the Tropics. Africa (Kamerun). America (Brazil, Surinam, Panama, Jamaica). Asia (Ceylon, Java, Philippine Islands).

Perithecia golden yellow, 0.4 to 0.7 by 0.25 to 0.4 mm, globose, rugose, gregarious; spores 3- (4 or 5-) septate, 23 to 30 by 6 to 8.5 μ, fusoid, slightly curved, rounded at both ends, light ocher in masses.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a medium thin, matted, pomegranate purple, rose pink, and rose red mycelium. Concentric lines of rose pink and rose red may be present. Older cultures, from 45 to 90 days of age, have a more-matted mycelium with irregular stromatic tufts, which is pomegranate purple with a Bordeaux ring at the base. The agar may be turned the same color in places. Large masses of warm buff and light orange yellow sporodochia and pionnotes are developed. Individual sporodochia may be produced in columns. Potato-agar plates 2 months old have a thin, closely matted, zonate mycelium that toward the edges of the plate is pinkish cinnamon and in the center spinel red. Buff yellow sporodochia and pionnotes masses are scattered over the plate.

Oat agar.—Cultures 21 days old have a closely matted, spinel red and Indian lake mycelium over the slant. Dense masses of buff yellow pionnotes and a few individual sporodochia are present.

Rice.—Cultures 20 days old are characterized by a medium scant, chiefly yellow ocher, and in a few places pomegranate purple mycelium, leathery in places. Pionnotal masses are pres-

ent over the rice. Two-month-old cultures have a more or less powdery mycelium that is yellow ocher with touches of ochraceous orange and cinnamon brown. Light buff, light brownish olive, and Isabella color pionnotes masses are produced.

Potato-tuber plug.—Cultures 25 days old have a medium thick, dense, felty, La France pink mycelium, tufted in places, with light buff sporodochia just developing. Older cultures, 80 days old, are similar with an addition of Bordeaux red in places. The pionnotal masses are large and buff yellow or honey yellow. Sporodochia in columns may also be present.

Melilotus stem.—Cultures 2 months old have a medium dense, closely matted, pale pinkish cinnamon mycelium over the stem. Pinkish buff and pinkish cinnamon sporodochia and pionnotes masses are produced.

Alnus stem.—Cultures 21 days old have a very scant aërial mycelium on the top of the twig. Pale pinkish cinnamon and pale pinkish buff sporodochia are formed from the lenticels in the twig.

Banana peel.—Cultures 38 days old have a scant, pale pinkish buff and pinkish buff mycelium. Cream buff and chamois sporodochia are developed.

Green bean pod.—Cultures 50 days old are characterized by a medium thin, matted mycelium that is cartridge buff, pale cinnamon pink, pale pinkish buff with spots of rose color. A cinnamon buff stroma erumpent may be present in a few places. Cinnamon buff and cinnamon pionnotes masses and sporodochia are produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 18 days old; conidia from mycelium and pionnotes:

Conidia—

0-septate, 52 per cent, 8 by 4 (5 to 9 by 3.25 to 4.5) μ.
1-septate, 17 per cent, 12 by 4.25 (10 to 18 by 3.5 to 4.5) μ.
2-septate, 5 per cent, 24 by 5.5 (22 to 27 by 5.25 to 6) μ.
3-septate, 5 per cent, 32 by 5.5 (30 to 36 by 5.5) μ.
4-septate, 4 per cent, 35 by 5.5 (33 to 36 by 5.5) μ.
5-septate, 9 per cent, 54 by 6.25 (42 to 68 by 5.5 to 7.25) μ.
6-septate, 5 per cent, 62 by 6.5 (57 to 68 by 6.25 to 7.25) μ.
7-septate, 3 per cent, 74 by 6.5 (70 to 81 by 6.25 to 7.25) μ.

Hard potato agar; culture 32 days old; conidia from sporodochia:

Conidia—

0-septate, 13 per cent, 7 by 4 (6 to 8 by 3.5 to 4.5) μ.
1-septate.
2-septate.
3-septate, 2 per cent, 25 by 4.5 μ.

4-septate, 2 per cent, 38 by 5 μ.
5-septate, 8 per cent, 59 by 6 (45 to 71 by 5.5 to 6.25) μ.
6-septate, 21 per cent, 66 by 6.25 (57 to 72 by 6.25) μ.
7-septate, 48 per cent, 70 by 6.25 (63 to 78 by 5.5 to 7.25) μ.
8-septate, 4 per cent, 72 by 6.25 (59 to 86 by 6.25) μ.
9-septate, 2 per cent, 78 by 6.25 (68 to 90 by 6.25) μ.

Green bean pod; culture 9 days old; conidia from sporodochia:
Conidia—
0-septate, 20 per cent, 7 by 3.25 (7 to 8 by 2.75 to 3.5) μ.
1-septate, 1 per cent, 17 by 4.5 μ.
2-septate.
3-septate.
4-septate, 3 per cent, 50 by 5.75 (41 to 59 by 5.5 to 6.25) μ.
5-septate, 4 per cent, 53 by 6 (52 to 54 by 6 to 6.25) μ.
6-septate, 41 per cent, 62 by 6.25 (56 to 73 by 5.5 to 7.25) μ.
7-septate, 15 per cent, 71 by 6.5 (60 to 83 by 5.5 to 7.25) μ.
8-septate, 6 per cent, 71 by 6.75 (59 to 78 by 6.25 to 7.25) μ.
9-septate, 10 per cent, 75 by 6.75 μ.

Water culture 21 days old; conidia from sporodochia:
Conidia—
6-septate, 1 per cent.
7-septate, 40 per cent.
8-septate, 27 per cent.
9-septate, 31 per cent.
10-septate, 1 per cent.
11- to 12-septate, rare.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
6-septate, 17 per cent, 63 by 6.25 (56 to 73 by 5.5 to 7.25) μ.
7-septate, 27 per cent, 72 by 6.25 (60 to 83 by 5.5 to 7.25) μ.
8-septate, 12 per cent, 72 by 6.5 (59 to 86 by 6.25 to 7.25) μ.
9-septate, 14 per cent, 77 by 6.5 (75 to 90 by 6.25 to 6.75) μ.

XII. Section SAUBINETII Wollenweber

Saubinetii WOLLENWEBER, Ann. Myc. 15 (1917) 2; WOLLENWEBER and REINKING, Phytopath. 15 (1925) 165.

Stroma spread out, floccose or dense, ochraceous, carmine; aërial mycelium from white to rose color; conidia scattered in sporodochia or in pinnotes, from pale orange to ochraceous, sickle-shaped, elongate, 3- to more-septate, constricted at top end, pedicellate at base, sometimes apedicellate; chamydospores absent. Some species have a perfect stage that is a *Gibberella* of the section *Saubinetii.*

FUSARIUM MACROCERAS Wollenweber and Reinking. Plate 2, fig. 3; text fig. 24.

Fusarium macroceras WOLLENWEBER and REINKING, Phytopath. 15 (1925) 166.

Stroma floccose, rose white, or dense plectenchymic, yellow, ochraceous, and carmine; conidia scattered, lanceolate or sickle-

shaped, dorsiventral, constricted at the top end, conical at the base, apedicellate, conidia in sporodochia and pionnotes, elongate, slightly sickle-shaped, attenuated at both ends, pedicellate, 5- to 7-septate, 47 to 64 by 4.5 to 5.75 (35 to 74 by 4 to 7) μ, fewer 1- to 4- or 8- or 9-septate, very seldom 14-septate, 150 by 6.25 μ; chlamydospores absent.

Habitat.—On mature bush-bean pods (*Phaseolus vulgaris* Linnæus). Tela, Honduras, Central America (*Reinking R 95*).

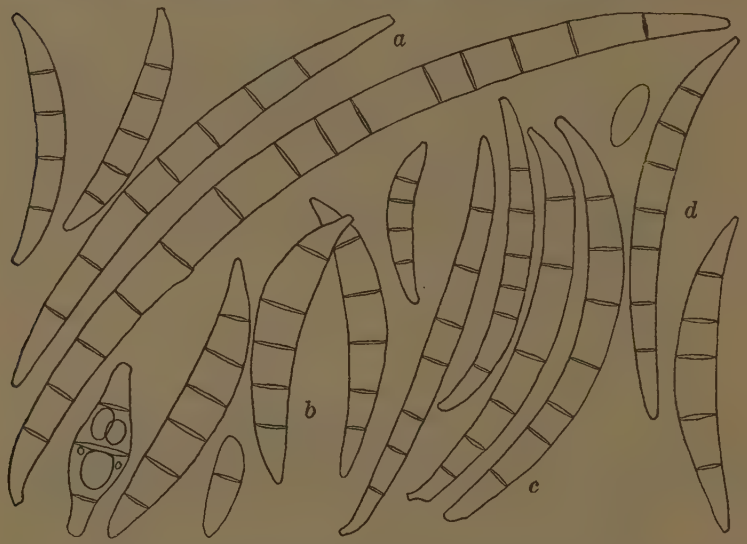

FIG. 24. *Fusarium macroceras* Wollenweber and Reinking; *a*, conidia, few abnormally large, from mycelium of 3-day-old oatmeal-agar culture; *b*, conidia, short and broad type, from mycelium of 2-month-old potato-tuber plug culture; *c*, conidia, typical long and slender type, from mycelium of 2-month-old hard potato-agar culture; *d*, conidia from mycelium of 19-day old *Alnus*-stem culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 5 days old are characterized by thin, matted, powdery and, in places, somewhat tufted mycelium that is white at the tips and pomegranate purple over the agar. Few spots of cinnamon brown may be present. Older cultures, up to 3 months of age, usually have a dense, matted, pale pinkish buff and spinel pink mycelium. The agar may be turned pomegranate purple and Bordeaux. Few cream buff pionnotes masses may be produced. On plates 2 months old a medium dense, seashell pink aërial mycelium is found. In the substra-

tum concentric rings of seashell pink and spinel red mycelium are developed.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 to 2 months old are characterized by a thick, dense, matted, pale flesh color, cameo pink, and spinel red aërial mycelium. In the substratum the mycelium is Bordeaux. A pomegranate purple stroma may be produced in places on the agar.

Oat agar.—Cultures 1 month old have a thick, dense mycelium that is white and pomegranate purple and Bordeaux at the edges of the growth. Dense, salmon color masses of pionnotes may be produced in places over the slant.

Rice.—Cultures 19 days old have a matted mycelium that is yellow ocher on the glass and over the rice, and Dresden brown to mummy brown in places. Pomegranate purple spots may be found. Older cultures, 2 months of age, are characterized by a matted, yellow ocher, buckthorn brown, and Dresden brown mycelium. Spots of olive ocher and pinkish buff may be present on the sides.

Potato-tuber plug.—Cultures 1 month old have a fluffy mycelium above and thick matted below that is seashell pink, pomegranate purple with Saccardo's umber here and there. Older cultures, 80 days old, are characterized by a matted and leathery mycelium that is pale pinkish buff and pomegranate purple with Bordeaux below on the cylinder.

Melilotus stem.—Cultures 2 months old have a thick, dense, matted, pale pinkish buff mycelium.

Alnus stem.—Cultures 1 month old have a medium scant, fine, white and light ochraceous buff mycelium here and there over the twig.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 32 days old; conidia from mycelium and pionnotes:

Conidia—

0-septate, 3 per cent, 5 by 1.75 (5 by 1.25 to 2.25) μ.
1-septate, 1 per cent, 23 by 4.5 μ.
2-septate, 1 per cent, 32 by 4.5 μ.
3-septate, 6 per cent, 34 by 4.25 (27 to 40 by 4 to 4.5) μ.
4-septate, 23 per cent, 43 by 5 (36 to 49 by 4 to 7) μ.
5-septate, 28 per cent, 47 by 5.75 (35 to 67 by 5 to 7) μ.
6-septate, 28 per cent, 52 by 6.25 (46 to 58 by 5.5 to 7) μ.
7-septate, 8 per cent, 60 by 6.25 (57 to 75 by 5.5 to 6.75) μ.
8-septate, 1 per cent, 66 by 6.25 μ.
9-septate, 1 per cent, 59 by 5.5 μ.

Potato-tuber plug; culture 2 months old; conidia from mycelium and pionnotes:

Conidia—

1-septate, 1 per cent.
2-septate, 1 per cent.
3-septate, 5 per cent, 29 by 6.25 (26 to 33 by 5.5 to 7) μ.
4-septate, 14 per cent, 35 by 7 μ.
5-septate, 25 per cent, 45 by 5.25 (42 to 48 by 3.5 to 7) μ.
6-septate, 20 per cent, 48 by 4.75 (45 to 51 by 4 to 5.5) μ.
7-septate, 20 per cent, 64 by 4.5 μ.
8-septate, 9 per cent, 60 by 5 μ.
9-septate, 4 per cent, 79 by 4.25 (73 to 85 by 4 to 4.5) μ.
10-septate, 1 per cent, 63 by 7 μ.

Oat agar; culture 3 days old; conidia from pionnotes:

Conidia—

4-septate, 2 per cent, 38 by 4 μ.
5-septate, 17 per cent, 46 by 5 μ.
6-septate, 12 per cent.
7-septate, 33 per cent, 79 by 5.25 μ.
8-septate, 12 per cent.
9-septate, 13 per cent.
10-septate, 9 per cent.
11-septate, 1 per cent, 93 by 5 μ.
14-septate, 1 per cent, 130 by 6.25 μ.

Alnus stem; culture 19 days old; conidia from mycelium:

Conidia—

4-septate, 3 per cent.
5-septate, 27 per cent, 47 by 6.25 μ.
6-septate, 31 per cent.
7-septate, 24 per cent, 61 by 5.5 (57 to 65 by 4.75 to 6.5) μ.
8-septate, 9 per cent.
9-septate, 6 per cent, 78 by 5.5 μ.
10-septate, rare, 70 by 5.75 μ.
11-septate, rare, 80 by 6.5 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—

5-septate, 24 per cent, 46 by 5.5 (35 to 67 by 3.5 to 7) μ.
6-septate, 23 per cent, 50 by 5.5 (45 to 58 by 4 to 7) μ.
7-septate, 21 per cent, 66 by 6.25 (57 to 79 by 4.5 to 6.75) μ.

XIII. Section ELEGANS Wollenweber

Elegans WOLLENWEBER, Phytopath. 3 (1913) 28; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 202; WOLLENWEBER, Ber. der Deutsch. Bot. Gesell. 35 (1918) 741.

Microconidia usually simple, 5 to 12 by 2 to 3.5 μ; macroconidia free, in tubercular sporodochia or confluent pionnotes, straight in some species, more or less sickle-shaped in others, end cells more curved than those in the center, from acuminate to constricted, base more or less pedicellate; blue sclerotia, formed

in many species. This section, otherwise very much like *Lateritium*, differs from the latter by having a large number of microconidia and terminal chlamydospores. Color type, vinaceous to violet. Many of these fungi cause wilt diseases; some of them also cause rots on various parts of cultivated plants.

1. Subsection ORTHOCERA Wollenweber

Orthocera WOLLENWEBER, Ann. Myc. 35 (1917) 2; Ber. der Deutsch. Bot. Gesell. 35 (1918) 741.

Sporodochia imperfect, usually absent, microconidia typically present. Conidia are nine to twelve times as long as thick.

FIG. 25. *Fusarium bostrycoides* Wollenweber and Reinking; *a*, conidia from mycelium of 23-day-old hard potato-agar culture; *b*, chlamydospores from mycelium of 23-day-old hard potato-agar culture; *c*, conidiophore, bostryxlike, from mycelium of 14-day-old *Melilotus*-stem culture, × 500.

FUSARIUM BOSTRYCOIDES Wollenweber and Reinking. Text fig. 25.

Fusarium bostrycoides WOLLENWEBER and REINKING, Phytopath. 15 (1925) 166.

Stroma plectenchymic from brownish white to green or violet; aërial mycelium cæspitose, cream color; microconidia numerous, scattered, or in false heads, formed on verticillate or bostryxlike, branched conidiophores; unicellular, ovoid, 6 to 11 by 2.5 to 3.25 (4 to 13 by 2 to 4) μ; very rarely 1-septate, 15 to 22 by 2.5 to 3.75 μ, and 3-septate, straight to slightly sickle-shaped, subpedicellate, 24 to 29 by 2.5 to 4 μ; sporodochia and pionnotes absent; chlamydospores numerous, terminal and in-

tercalary, globose, unicellular or in chains, rugose, 6 to 8 μ in diameter.

Habitat.—In soil. Tela, Honduras, Central America (*Reinking R 169*).

The fungus on rice culture has a rosy acid modification of color, changing to blue by addition of sufficient alkali.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Culture 12 days old characterized by a scant, thin matted, tufted in places, cartridge buff and Saccardo's slate mycelium. Older cultures, from 1 to 3 months old, have a short, woolly, medium scant, thin matted, sometimes powdery mycelium that is cream color, cartridge buff, and cinnamon buff with deep slate olive at the base of the slant. Potato-agar plates 2 months old have a medium thin, short, woolly and powdery, zonate, pinkish buff mycelium over the plate.

Oat agar.—Cultures 15 days old have an aërial mycelium that is dense, matted, woolly, and powdery in places. It is pale pinkish buff, dark grayish lavender, slate violet(1) and slate blue with purplish vinaceous in places.

Rice.—Cultures 19 days old have a medium scant and matted, felty, white, dark vinaceous purple, neutral red, and dark Corinthian purple mycelium over the rice. The rice turns shrimp pink. Cultures 2 months old are characterized by a matted mycelium with a combination of neutral red, dark vinaceous purple, Indian lake, and cartridge buff above, and on the sides pale pinkish cinnamon and dark vinaceous brown. The rice is shrimp pink and hydrangea pink.

Potato-tuber plug.—Cultures 21 days old have a matted white and light buff mycelium. Older cultures, 80 days old, are characterized by a thin, matted, felty, and leathery mycelium that is pinkish buff and olivaceous black in places.

Melilotus stem.—Cultures 24 days old have a woolly, pinkish buff mycelium with powdery tufts in places over the stem.

MEASUREMENTS OF CONIDIA

Hard potato agar; cultures 23 days old; conidia from mycelium:

Conidia—

0-septate, 94 per cent, 9 by 3 (4 to 13 by 2 to 4) μ.

1-septate, 2 per cent, 19 by 3 (15 to 22 by 2.5 to 3.5) μ.

2-septate.

3-septate, 4 per cent, 27 by 3.25 (24 to 29 by 2.5 to 4) μ.

FUSARIUM ORTHOCERAS Appel and Wollenweber. Text fig. 26.

Fusarium orthoceras APPEL and WOLLENWEBER, Arb. Kais. Biol. Anst. Land- u. Forstw. 8 (1910) 141–156; WOLLENWEBER, Phytopath. 3 (1913) 30; Journ. Agr. Research 2 (1914) 263–264; LEWIS, Maine Agr. Exp. Sta. Bull. 219 (1913) 203–258; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 202–203; WOLLENWEBER, Ann. Myc. 15 (1917) 23.

Conidia as a rule unicellular, averaging 5 to 12 by 2.5 to 3.5 μ, embedded in a cottony mycelium layer, often jellied with age; sporodochia and pionnotes absent; sclerotia absent. A few, not exceeding 15 per cent, of the conidia may be 3-septate, 25 to 46 by 3 to 4 μ; septal zone nearly cylindrical, slightly curved at the apical end, which is inequilateral-conical; base nearly straight-conical or appendicular, seldom subpedicellate, 4- and

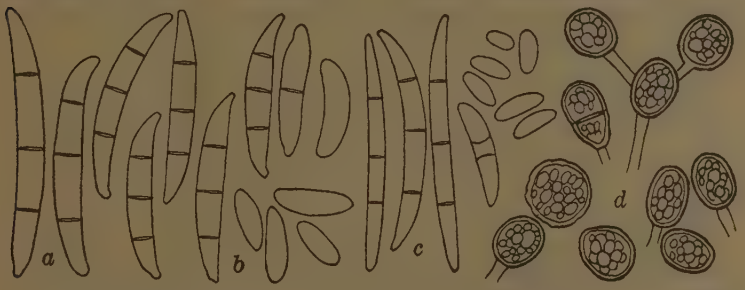

FIG. 26. *Fusarium orthoceras* Appel and Wollenweber; *a*, conidia from mycelium of 15-day-old hard potato-agar culture; *b*, conidia from mycelium of 14-day-old oatmeal-agar culture; *c*, conidia from mycelium of 2-month-old potato-tuber plug culture; *d*, chlamydospores from mycelium of 2-month-old hard potato-agar culture.

5-septate conidia rare, averaging up to 50 by 4 μ; conidiophores with irregularly arranged sterigmata, seldom trifurcate. The fungus is ocherous to salmon color in light, in darkness it fades to brownish white. Thalloplectenchymata wine red in the acid modification (on rice) and blue spotted in the basic modification (on potato tubers); sclerotial plectenchymata entirely wanting. Chlamydospores intercalated, globose to ovoid, 1-celled forms averaging 7 to 10 μ, 2-celled forms rarer, but with a somewhat larger major longitudinal axis.

Habitat.—In soil. Tela, Honduras, Central America (*Reinking R 162*). On diseased cacao pod (*Theobroma cacao* Linnæus) and in the soil. Jamaica (*Hansford 2 and 13, R 223* and *232*).

The parasitic nature of this fungus on bananas has not been carefully tested.(7) It is highly possible that *F. orthoceras* may

have some relation to banana-root troubles. It may also be the cause of a rot of potato tubers in the United States. A rot of apple and cucumber fruit is produced upon inoculation.(6)

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 14 days old are characterized by a fine, thick, matted mycelium that is white, ivory yellow, cream buff, sometimes with dark slate violet(1) concentric rings about the point of transfer on agar. Older cultures, between 1 and 3 months of age, are the same, but with an addition of cartridge buff, cream buff, chamois, and soft bluish violet. The mycelium may be matted, cottony, or gelatinous (self-digested). On potato-agar plates 2 months old a scant, pale pinkish buff mycelium is produced.

Potato agar, 5 per cent dextrose.—Cultures 1 month old had no aërial mycelium. The mycelium in the substratum was dark maroon-purple.

Oat agar.—Cultures 22 days old have a short, dense, matted, aërial mycelium, that is white and pale cinnamon pink with vinaceous and pinkish vinaceous on the sides at the base of the slant.

Rice.—Cultures 21 days old have a medium scant, thulite pink, spinel red, and light rosolane purple mycelium. Older cultures, from 1 to 2 months of age, are characterized by a leathery mycelium that ranges from dusky violet-blue (2) on top to dark dull bluish violet (3) and dusky dull violet (1) below. In places it may be cream buff, yellow ocher, and sayal brown. A slight benzolic odor is present.

Potato-tuber plug.—Cultures 22 days old have a medium dense, leathery, white and cream color mycelium, possibly with spots of dark chessylite blue or dark dull blue-violet in places. Older cultures, from 1 to 2 months old, have a thin, wet leathery, cream buff and chamois mycelium with Saccardo's slate in places.

Melilotus stem.—Cultures 1 month old have a medium scant, white and cinnamon buff mycelium over the stem.

Alnus stem.—Growth on *Alnus* is similar to that on *Melilotus.*

Mature corn stalk.—Cultures 54 days old have a medium dense, and in places a leathery mycelium that is cream buff, honey yellow, and pale olive buff.

Banana peel.—Cultures 26 days old have a medium scant, coarse, matted, wet in places, white, pale pinkish buff, or

cinnamon buff mycelium. Older cultures, up to 3 months of age, have a scant, white, cartridge buff, and pinkish buff mycelium. Patches of pale ochraceous buff and antimony yellow may appear where the mycelium touches the glass.

Banana fruit flesh.—Cultures 26 days old have a dense, and in places matted, white, light buff, and buckthorn brown mycelium.

Green bean pod.—Cultures 1 to 2 months old have a medium dense, cartridge buff, cream buff, light pinkish buff, pinkish buff, or pale cinnamon pink mycelium over the bean. It may be clay color where it touches the glass. Self digestion may also occur.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 30 days old; conidia from mycelium:
Conidia—
0-septate, 61 per cent, 9 by 3 (5 to 18 by 2.75 to 4.5) μ.
1-septate, 14 per cent, 14 by 3.5 (11 to 18 by 3.25 to 4.5) μ.
2-septate, 5 per cent, 20 by 4 (15 to 23 by 3.25 to 4.5) μ.
3-septate, 18 per cent, 32 by 3.75 (22 to 41 by 3.25 to 4.5) μ.
4-septate, 1 per cent, 33 by 4 μ.
5-septate, 1 per cent, 43 by 4.5 μ.
6-septate, rare, 47 by 5 μ.

Green bean pod; culture 1 month old; conidia from mycelium:
Conidia—
0-septate, 70 per cent, 8 by 3 (5 to 14 by 2.75 to 3.5) μ.
1-septate, 15 per cent, 17 by 3.5 (14 to 20 by 3.25 to 4) μ.
2-septate, 2 per cent, 20 by 3.5 (18 to 22 by 3.5) μ.
3-septate, 13 per cent, 28 by 3.75 (23 to 32 by 3.5 to 4.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—
0-septate, 65 per cent, 9 by 3 (5 to 18 by 2.75 to 4.5) μ.
1-septate, 14 per cent, 15 by 3.5 (11 to 20 by 3.25 to 4.5) μ.
2-septate, 4 per cent, 20 by 3.75 (15 to 23 by 3.25 to 4.5) μ.
3-septate, 15 per cent, 30 by 3.75 (22 to 41 by 3.25 to 4.5) μ.

FUSARIUM ORTHOCERAS Appel and Wollenweber var. TRISEPTATUM Wollenweber. Text fig. 27.

Fusarium orthoceras triseptatum WOLLENWEBER, Journ. Agr. Research 2 (1914) 264–267.

Differs from *Fusarium orthoceras* in having a higher septation of conidia, by the presence of sporodochia and a reduced pionnotes. Under normal conditions, as many as 100 per cent of the conidia are 3-septate; 10 per cent of 4- and 5-septate conidia are found; unicellular or small-septate conidia and chlamydospores occur and prevail under certain conditions.

Habitat.—On decaying bunch of bananas (*R 45*), in the interior of the pseudostem of a diseased banana plant (*Musa*

sapientium Linnæus), and in the soil. Tela and Trujillo, Honduras, Central America (*Reinking R 45*).

Soil inoculation about banana plants failed to produce infection.(7)

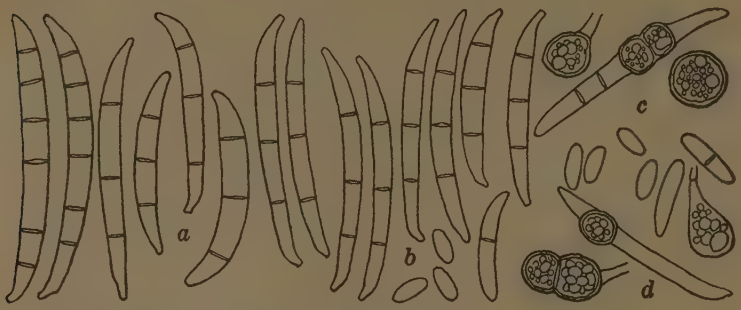

FIG. 27. *Fusarium orthoceras* Appel and Wollenweber var. *triseptatum* Wollenweber; *a*, conidia from mycelium of 16-day-old hard potato-agar culture; *b*, conidia from mycelium of 11-day-old hard potato-agar culture; *c*, chlamydospores from 32-day-old hard potato-agar culture; *d*, chlamydospores from 16-day-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 14 days old have a thin, cottony, and dense, matted, white, ivory yellow, and cream color mycelium. Older cultures, 1 to 3 months of age, are characterized by a white, cottony, and leathery, pale ochraceous buff, ivory yellow, and cream buff mycelium. A pale ochraceous buff, self-digested mass may be present.

Oat agar.—Cultures 1 month old have a medium dense, short, matted, pale pinkish cinnamon mycelium over the agar. A dull dusky purple stroma may be produced in places.

Rice.—Cultures 21 days old have a dense, matted, white, cameo pink, thulite pink, and spinel pink mycelium. Cultures 1 to 2 months old have a fluffy to leathery mycelium that is white, pinkish buff, cream color, thulite pink, and dark dull bluish violet.(1) The rice remains clear. A slight benzolic odor is present.

Potato-tuber plug.—Young cultures have a dense, matted, white mycelium. Cultures 81 days old are the same with an addition of cartridge buff and cream buff.

Melilotus stem.—Cultures 1 month old have a scant, pinkish buff, clay color, and tawny olive mycelium. The aërial mycelium may be self-digested. Cinnamon buff sporodochia are produced.

Alnus stem.—Cultures 1 month old have a medium scant, pinkish cinnamon and cinnamon mycelium over the top of the twig.

Mature corn stalk.—Cultures 1 month old have a scant, fluffy, white, aërial growth. At the age of 53 days the mycelium has changed to dark slate violet.(1)

Banana peel.—Cultures 26 days old have a medium scant, matted, white mycelium; cream color, dark terre-verte, and mummy brown stromatic bodies may be produced.

Banana-fruit flesh.—Cultures 26 days old have a dense, matted, white mycelial growth.

Green bean pod.—Cultures 1 to 2 months old have a medium scant mycelium that is flattened over the bean and is cartridge buff and pale pinkish buff. The mycelium may be slimy or self digested, and olive buff with vinaceous buff. Cinnamon buff stromatic masses may be produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 40 days old; conidia from mycelium:
Conidia—
0-septate, 64 per cent, 10 by 3 (5 to 15 by 2.75 to 3.5) μ.
1-septate, 20 per cent, 16 by 3.5 (13 to 22 by 3.25 to 3.5) μ.
2-septate, 2 per cent, 25 by 3.5 (23 to 25 by 3.5) μ.
3-septate, 12 per cent, 36 by 3.5 (24 to 41 by 3.25 to 3.5) μ.
4-septate, 1 per cent, 41 by 3.5 (31 to 43 by 3.25 to 3.5) μ.
5-septate, 1 per cent, 38 by 4 (35 to 41 by 3.5 to 4) μ.

Green bean pod; culture 8 days old; conidia from mycelium:
Conidia—
0-septate, 44 per cent, 9 by 3 (5 to 14 by 2.75 to 3.5) μ.
1-septate, 19 per cent, 17 by 3.75 (14 to 22 by 3.5 to 4) μ.
2-septate, 1 per cent, 23 by 3.5 μ.
3-septate, 35 per cent, 32 by 4.25 (22 to 41 by 4 to 4.5) μ.
4-septate, 1 per cent, 40 by 4.5 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—
0-septate, 54 per cent, 9 by 3 (5 to 15 by 2.75 to 3.5) μ.
1-septate, 19 per cent, 16 by 3.5 (13 to 22 by 3.25 to 4) μ.
2-septate, 1 per cent, 24 by 3.5 (23 to 25 by 3.5) μ.
3-septate, 24 per cent, 34 by 3.75 (22 to 41 by 3.25 to 4.5) μ.
4-septate, 1 per cent, 40 by 4 (31 to 43 by 3.25 to 4.5) μ.
5-septate, 1 per cent, 40 by 4.5 (35 to 41 by 3.5 to 4) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Hard potato agar; culture 1 month old:
Chlamydospores—
0-septate, conidial, chlamydospores, 65 per cent, 7.25 by 7.75 (6.5 to 8.25 by 6 to 7.25) μ.
1 septate, conidial, chlamydospores, 35 per cent, 10 by 6 (9 to 11 by 5.5 to 6.5) μ.

2. Subsection CONSTRICTUM Wollenweber (sensu stricto)

Constrictum WOLLENWEBER, Ann. Myc. 15 (1917) 2 (excl. *F. moniliforme* Sheldon).

Sporodochia present. Conidia slender, narrow, constricted at top end, pedicellate chlamydospores common and typical. Type species, *F. batatatis* Wollenweber.

FUSARIUM BULBIGENUM Cooke and Massee. Text fig. 28.

Fusarium bulbigenum COOKE and MASSEE, Grevillea 16 (1887) 49; SACCARDO, Syll. Fung. 10 (1892) 725; MASSEE, Brit. Fung. Flor. 3 (1893) 482; Kew Bull. No. 8 (1913) 307–309; WOLLENWEBER, Jahresber. Ver. f. Angew. Bot. 14 (1916) 2, 125; Ann. Myc. 15 (1917) 23.

Mycelium effused, white and cartridge buff, stroma occasionally violet, at first somewhat erumpent in small tufts and later confluent. Microconidia unicellular, 9 to 10 by 2.75 to 3.5 μ; 1-septate, 14 to 21 by 2.75 to 3.5 μ in abundance in aërial mycelium

FIG. 28. *Fusarium bulbigenum* Cooke and Massee; *a*, conidia from mycelium and pionnotes of 16-day-old oatmeal-agar culture; *b*, conidia from minute sporodochia of 14-day-old *Alnus*-stem culture; *c*, chlamydospores from mycelium of 15-day-old oatmeal-agar culture and from minute sporodochia of 14-day-old *Alnus*-stem culture.

and often prevailing. Pionnotes ochraceous salmon or warm buff; develops the typical long conidia, fusiform arcuate or incurved at the acute extremities, more or less pedicellate at the base; 3-septate, 26 to 50 by 2.75 to 4 μ; rarely 4- to 5-septate; 4-septate, 33 to 52 by 2.75 to 4 μ; 5-septate, 41 to 56 by 2.75 to 3.75 μ.

Chlamydospores common, terminal and intercalary, 5 to 9 μ in diameter.

Habitat.—On cut surface of banana rhizome (*Musa sapientium* Linnæus) (*R 49*) and in the soil. Trujillo and Tela, Honduras, Central America (*Reinking R 49*).

Fusarium bulbigenum produces a wilt and rot of bulbs of *Narcissus.*

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 4 to 14 days old are characterized by a fine cottony and fluffy mycelium that is white, cartridge buff, and at the base of the slant pale ochraceous salmon. A scant pionnotes of the latter color may be present. Cultures from 44 to 63 days old have a cottony and matted, cartridge buff, cream buff, and pale ochraceous buff mycelium. A warm buff pionnotes may be produced. Large wartlike heaps of amber yellow and warm buff sclerotia are frequently formed. On potato-agar plate 2 months old is produced a medium scant, pale pinkish buff mycelium.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have no aërial mycelium, but that in the substratum is dark vinaceous.

Oat agar.—Cultures 1 month old have a dense, matted, fine mycelium that is white, pale cinnamon pink with nigrosin violet at the sides of the growth. A warm buff pionnotes may be present.

Rice.—Cultures 21 days old are characterized by a medium dense and matted, white, cameo pink, thulite pink, rosolane purple, and Indian lake mycelium. Small whitish wartlike sclerotia may be present. Older cultures, from 1 to 2 months old, have a medium dense, fluffy and matted, cameo pink, thulite pink, and pomegranate purple mycelium. It may be leathery in places and yellow ocher. Sclerotia are present and a light pinkish cinnamon pionnotes may be produced. A slight benzolic odor is noted.

Potato-tuber plug.—Cultures 23 days old have a dense, cottony, white and seashell pink mycelium. Warm buff, wartlike sclerotia are present. Cultures 1 month to 80 days old have a dense cottony, in places leathery, white and light violet mycelium. On the glass the mycelium may be yellow ocher.

Melilotus stem.—Cultures 1 month old have a scant, pale pinkish buff mycelium.

Alnus stem.—Cultures 1 month old have a medium scant, pinkish cinnamon and cinnamon mycelium.

Mature corn stalk.—Cultures from 30 to 50 days old have a scant, in places powdery and in tufts, white, light buff, and cream color mycelium. It also may be mustard yellow in places.

Banana peel.—Cultures 26 days old have a scant, white and honey yellow mycelium. Three-month-old cultures are characterized by a scant, matted, sayal brown mycelium. Small white sclerotia may be produced.

Green bean pod.—Cultures 1 month old have a dense, white mycelium, typically with cream buff sclerotia. Older cultures, 1 to 2 months old, have a thin, sometimes velvety, matted, cartridge buff, pale pinkish buff, and cinnamon buff mycelium. Under certain conditions self digestion of the mycelium may take place. The slimy mass is then a deep olive buff.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 1 month old; conidia from mycelium:
Conidia—
0-septate, 57 per cent, 9 by 2.75 (5 to 15 by 2.25 to 3.5) μ.
1-septate, 22 per cent, 14 by 3.5 (9 to 18 by 3.25 to 4) μ.
2-septate, 3 per cent, 23 by 3.5 (19 to 29 by 3.25 to 4) μ.
3-septate, 13 per cent, 38 by 3.75 (29 to 45 by 3.5 to 4) μ.
4-septate, 2 per cent, 40 by 3.75 (35 to 47 by 3.5 to 4) μ.
5-septate, 2 per cent, 63 by 3.5 (41 to 46 by 3.5) μ.
6-septate, 1 per cent, 49 by 3.5 μ.

Oat agar; culture 16 days old; conidia from mycelium and pionnotes:
Conidia—
0-septate, 3 per cent.
1-septate, 1 per cent.
2-septate.
3-septate, 82 per cent, 35 by 3.25 (26 to 45 by 2.75 to 3.5) μ.
4-septate, 12 per cent, 43 by 3.25 (33 to 52 by 2.75 to 3.5) μ.
5-septate, 2 per cent, 49 by 3.25 (42 to 56 by 2.75 to 3.75) μ.

Green bean pod; culture 14 days old; conidia from mycelium:
Conidia—
0-septate, 61 per cent, 10 by 3.5 (6 to 13 by 2.75 to 4) μ.
1-septate, 14 per cent, 21 by 2.75 (20 to 23 by 2.75 to 3.25) μ.
2-septate, 4 per cent, 23 by 3.75 (18 to 27 by 3.5 to 4) μ.
3-septate, 21 per cent, 31 by 3.5 (29 to 33 by 3.25 to 3.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—
0-septate, 40 per cent, 9 by 3 (5 to 15 by 2.25 to 4) μ.
1-septate, 10 per cent, 17 by 3.25 (9 to 23 by 2.75 to 4) μ.
2-septate, 2 per cent, 23 by 3.5 (18 to 29 by 3.25 to 4) μ.
3-septate, 40 per cent, 36 by 3.5 (26 to 45 by 2.75 to 4) μ.
4-septate, 6 per cent, 41 by 3.5 (33 to 52 by 2.75 to 4) μ.
5-septate, 2 per cent, 46 by 3.25 (41 to 56 by 2.75 to 3.75) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Hard potato agar; culture 112 days old:
Chlamydospores (both conidial and mycelial)—
0-septate, conidial chlamydospores, 96 per cent, 6.5 by 5.5 (5.5 to 8 by 5 to 6.25) μ.
1-septate, conidial chlamydospores, 4 per cent, 10.5 by 4.75 (10 to 11 by 4.5 to 5) μ.
0-septate, mycelial chlamydospores, 82 per cent, 9 by 9 μ.
1-septate, mycelial chlamydospores, 8 per cent, 13.5 by 7 μ.

3. Subsection OXYSPORUM Wollenweber

Oxysporum WOLLENWEBER, Ann. Myc. 15 (1917) 2; Ber. der Deutsch. Bot. Gesell. 35 (1918) 741.

Sporodochia typically present, stroma more or less verrucose erumpent, sclerotia present, microconidia common. Macroconidia eight to ten times as long as thick.

Series CYANOSTROMA Wollenweber

Cyanostroma WOLLENWEBER, Ann. Myc. 15 (1917) 2; Ber. der Deutsch. Bot. Gesell. 35 (1918) 742.

Stroma more or less erumpent, tinged with blue.

FUSARIUM OXYSPORUM Schlechtendal emend. Wollenweber. Plate 2, fig. 4; text. fig. 29.

Fusarium oxysporum SCHLECHTENDAL, Fl. Berol. 2 (1824) 139; SMITH and SWINGLE, U. S. Bur. Plant Ind. Bull. 55 (1904); WOLLENWEBER, Phytopath. 3 (1913) 28; Journ. Agr. Research 2 (1914) 268; CARPENTER, Journ. Agr. Research 5 (1915) 183–209; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 220; WOLLENWEBER, Jahresber. d. Ver. f. Angew. Bot. 14 (1916) 2, 121–128; Ann. Myc. 15 (1917) 24; Ber. der Deutsch. Bot. Gesell. 35 (1918) 742; BISBY, Minn. Agr. Exp. Sta. Bull. 181 (1919) 1–47.

Sclerotial plectenchymic stroma knotty rugulose, dark blue, erumpent; conidia somewhat Isabella color or dirty yellow, in sporodochia or pionnotes, sporodochia spread out, convex to confluent; conidia spindle- to sickle-shaped, pedicellate, end cell somewhat constricted, typically 3-septate, 30 by 4 (18 to 40 by 3.25 to 4.5) μ; rarer (up to 30 per cent), 4- to 5-septate, 35 by 4 (32 to 42 by 3.5 to 4.75) μ; microconidia formed free in aërial mycelium that is grayish white, or in numerous false heads, globose, single-celled, 5 to 12 by 2 to 3.5 μ, chlamydospores globose, sometimes verrucose, single-celled, rarer 1-septate, 7 to 10 μ in diameter. On rice culture the fungus produces a benzolic odor.

Habitat.—In soil. Tela, Honduras, Central America (*Reinking R 138*).

Fusarium oxysporum is the cause of potato wilt of plants in various parts of the world. It also produces a tuber rot and a jelly end-rot of tubers along with *F. radicicola*. Upon inoculation, rots are produced in orange, tomato, cucumber, and apple fruits.(3)

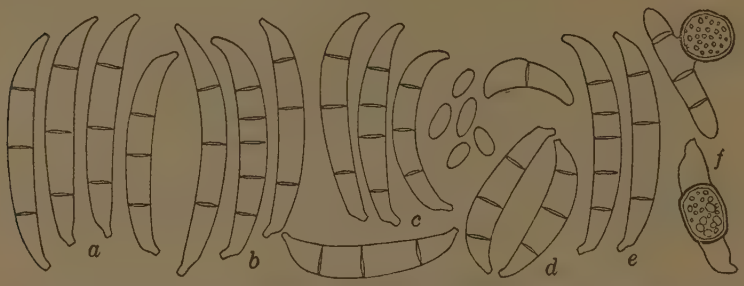

FIG. 29. *Fusarium oxysporum* Schlechtendal emend. Wollenweber; *a*, conidia from pionnotes of 2-month-old rice culture; *b*, conidia from pionnotes of 25-day-old hard potato-agar culture; *c*, conidia from pionnotes of 25-day-old hard potato-agar culture; *d*, conidia, short type, from sporodochia of 17-day-old *Melilotus*-stem culture; *e*, conidia from pionnotes of 23-day-old hard potato-agar culture; *f*, chlamydospores from 3-month-old green bean-pod culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a fluffy and dense, matted, white, cartridge buff, and ivory yellow mycelium. Terre-verte spots may be present at the base of the slant. A pinkish buff or pale ochraceous buff pionnotes is produced. Light buff and terre-verte sclerotia usually are developing. Cultures 45 to 90 days of age have a flattened and somewhat leathery, cartridge buff, cream buff, and shell pink mycelium. Dusky bluish green and deep delft blue wartlike sclerotia are usually present. Spots of dusky bluish green and bluish lavender may be present at the base as a sclerotial plectenchymic mass. A cream buff and pinkish buff sporodochial pionnotes may be present. On 2-month-old plates there are present a medium thin, pale pinkish buff mycelium and light ochraceous salmon sporodochia and pionnotes masses.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a medium scant, cottony, pale pinkish buff mycelium. Dusky dull bluish green sclerotia may be present here and

there over the plate. The mycelium in the substratum is burnt lake.

Oat agar.—Cultures 1 month old are characterized by a medium dense, somewhat matted, fine cottony, pale cinnamon pink and cameo pink mycelium. Spots of magenta red stroma may be present on the agar. Numerous large sclerotial masses 1 to 4 mm in diameter are usually present. When young they are light buff and when older dusky dull bluish green and deep delft blue. Salmon buff sporodochia and pionnotes masses are generally produced over the sclerotia and in places on the slant.

Rice.—Cultures 20 days old have a medium dense and matted, white, rose red, pomegranate purple, and rose color mycelium from the top to the bottom of the rice culture. An orange pink pionnotes may be present. The red color shows the acid modification. Cultures 2 to 3 months of age have a matted, spinel red, thulite pink, dark maroon-purple, madder violet, dark madder violet, and dull violet-black mycelium. The purple color shows the alkaline modification. Few dark maroon-purple sclerotia may be produced. Shrimp pink and salmon buff pionnotes masses are usually present. A strong benzolic odor is produced on rice.

Potato-tuber plug.—Cultures 22 days old have a scant, white and pale pinkish buff aërial mycelium, possibly with a spot or so of a dusky green-blue.(1) Wartlike heaps of sclerotia are usually present. When young they are warm buff and when older dusky green-blue(1) or deep delft blue. A pale ochraceous buff and light ochraceous salmon pionnotal mass is produced over the plug. Cultures 80 days old are similar except that a deep glaucous green and light porcelain green may be present on the sporodochia. The mycelium may also be pinkish buff and pale bluish lavender.

Melilotus stem.—Two-month-old growth is characterized by a medium scant, pale pinkish buff and pinkish buff mycelium over the stem. Small stromatic bodies of mycelium may be here and there. Light buff, warm buff, and dusky dull bluish green sclerotia in wartlike heaps, 1 to 3 mm in diameter, are present. They are usually covered with an ochraceous salmon pionnotes.

Alnus stem.—Cultures 1 month old have scant, pinkish buff mycelium on the twig with small, pale pinkish buff sporodochia here and there.

Mature corn stalk.—Cultures 54 days old have a fluffy and, in places, dense, white, seashell pink, terre-verte, and dusky dull violet(1,2) mycelium. Vinaceous cinnamon or blue-violet-black minute sclerotia may be produced.

Banana peel.—Young cultures, 26 days old, have a medium scant, cottony, white mycelium with sclerotia in dusky bluish green wartlike heaps and few honey yellow sporodochia. Older cultures, up to 95 days old, have a scant, cartridge buff, pale ochraceous buff, and cinnamon buff mycelium. The sclerotia are light buff, warm buff, dusky olive green, dusky bluish green, deep delft blue, sayal brown, and blackish green-gray. Pinkish cinnamon, light ochraceous salmon, and light ochraceous buff sporodochia and pionnotes masses are present.

Banana fruit flesh.—Cultures 26 days old have a thin, matted, pale pinkish buff and light pinkish cinnamon mycelium.

Green bean pod.—Cultures 2 months old are characterized by a thin, matted, cartridge buff, cream buff, pale pinkish buff, pinkish buff, and cinnamon buff mycelium. Cinnamon buff and dusky bluish green sclerotia are produced. Few cinnamon buff and light ochraceous salmon sporodochia are present.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 14 days old; conidia from sporodochia:
Conidia—
0-septate, 3 per cent, 6 by 3.25 (4 to 8 by 2.25 to 4.5) μ.
1-septate, 4 per cent, 14 by 3.75 (12 to 18 by 3.5 to 4) μ.
2-septate, 2 per cent, 19 by 4.5 (18 to 22 by 4.5) μ.
3-septate, 69 per cent, 25 by 4.5 (20 to 29 by 3.75 to 4.5) μ.
4-septate, 18 per cent, 43 by 5 (43 to 44 by 5) μ.
5-septate, 4 per cent, 44 by 5 μ.

Hard potato agar; culture 25 days old; conidia from pionnotes:
Conidia—
3-septate, 68 per cent, 28 by 3.75 (23 to 32 by 3.5 to 4) μ.
4-septate, 30 per cent, 33 by 4 (30 to 36 by 4 to 4.52) μ.
5-septate, 2 per cent, 36 by 4 (32 to 39 by 4 to 4.25) μ.

Rice; culture 2 months old; conidia from pionnotes:
Conidia—
3-septate, 82 per cent, 34 by 4 (30 to 38 by 4 to 4.25) μ.

Melilotus; culture 17 days old; conidia from sporodochia:
Conidia—
3-septate, 26 by 4 (22 to 30 by 3.5 to 4.5) μ.

Alnus; culture 14 days old; conidia from sporodochia:
Conidia—
3-septate, 27 by 3.75 (23 to 31 by 3.25 to 4) μ.

Green bean pod; culture 21 days old; conidia from sporodochia:
Conidia—
1-septate, 18 per cent, 9 by 2.5 (5 to 12 by 2.25 to 3.5) μ.
1-septate, 12 per cent, 17 by 4.25 (14 to 19 by 4 to 4.5) μ.

2-septate, 10 per cent, 18 by 4.25 (16 to 20 by 4 to 4.5) μ.
3-septate, 52 per cent, 21 by 4.75 (18 to 24 by 4 to 5) μ.
4-septate, 5 per cent, 38 by 5 (37 to 39 by 5) μ.
5-septate, 3 per cent, 39 by 5 (35 to 41 by 5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

0-septate, 6 per cent, 8 by 2.75 (4 to 12 by 2.25 to 4.5) μ.
1-septate, 4 per cent, 15 by 4 (12 to 19 by 3.5 to 4.5) μ.
2-septate, 4 per cent, 18 by 4.25 (16 to 22 by 4 to 4.5) μ.
3-septate, 68 per cent, 29 by 4.25 (18 to 38 by 3.25 to 5) μ.
4-septate, 15 per cent, 38 by 4.75 (30 to 44 by 4 to 5) μ.
5-septate, 3 per cent, 41 by 4.75 (32 to 44 by 4 to 5) μ.

FIG. 30. *Fusarium oxysporum* Schlechtendal var. *nicotianae* Johnson; *a*, conidia, long and short types, from pionnotes of 28-day-old potato-agar culture; *b*, conidia from pionnotes of 22-day-old rice culture; *c*, conidia from pionnotes of 22-day-old *Melilotus*-stem culture; *d*, conidia from pionnotes of 22-day-old *Melilotus*-stem culture; *e*, chlamydospores from 22-day-old *Melilotus*-stem culture and 2-month-old hard potato-agar culture; *f*, conidiophore, portion, from pionnotes of 3-month-old hard potato-agar culture.

FUSARIUM OXYSPORUM Schlechtendal var. NICOTIANAE Johnson. Plate 2, fig. 5; Plate 3, figs. 7 and 8; text fig. 30.

Fusarium oxysporum nicotianae JOHNSON, Journ. Agr. Research 20 (1921) 515–535; WOLLENWEBER, Angew. Bot. Zeit. für Erf. der Nutzpfl. 4 (1922) 9.

Johnson's diagnosis is as follows:

Mycelium pure white to light pinkish tinge, rather powdery due to presence of numerous microconidia; blue and light ochra-

ceous salmon color sclerotia found early on steamed potato; salmon color sporodochia and pionnotes present; conidia 3- to 5-septate, slightly larger than those of *F. oxysporum;* 3-septate, 35 by 4 (25 to 46 by 3.75 to 4.5) μ; 5-septate, 44 by 4 (39 to 51 by 3.75 to 4) μ; 6-septate, very rare; 0-septate, in sporodochia, rare, 7 by 2.5 μ; 1-septate, equally rare, 10 by 2.75 μ; 2-septate, 19 by 3.75 μ; 0-septate, from mycelium, 8 by 3.5 (4 to 10 by 2.75 to 3.75) μ; chlamydospores terminal, intercalary, mycelial and conidial, smooth, round, and frequently in masses, 8 (6 to 10) μ.

Differs from *F. oxysporum* by having longer conidia, up to 35 per cent 4- to 5-septate, 40 to 50 by 3.5 to 4.73 μ. Two types of spores are usually produced, long and narrow from pionnotes and sporodochia, short and wide from mycelium.

No benzolic odor is produced on rice by the strain described in the present discussion.

Habitat.—In soil. Tela and Trujillo, Honduras, Central America (*Reinking R 119*).

Fusarium oxysporum var. *nicotianae* is the cause of a tobacco wilt in the United States, but the pathogenicity of the soil fungus described here has not yet been proved. It is prevalent in the soil of banana plantations, having been found in 7 per cent of the total soil isolations.[9]

[9] Experience has shown that such characters as slenderness, curvature, and size of normal conidia can only be relied upon under uniform conditions in so-called "high culture." Slight differences in these characters may, however, occur in growing the same fungus in single-spore cultures, both from one source and from different hosts or locations. Under such circumstances the fungus described here, as isolated from Honduras soil and identified as *F. oxysporum* var. *nicotianae,* may touch the border line or may be even a widespread saprophytic soil form of the banana wilt *Fusarium, F. cubense.* This saprophytic soil strain may have adapted itself to plants of economic importance, as *Musa* or other plants, gradually assuming parasitic habits. If this were so, *F. cubense* would include saprophytic and parasitic strains with or without odor, taxonomically speaking, at least the following four forms:

Forma 1: Saprophytic form producing a benzolic odor.
Forma 2: Saprophytic form without odor.
Forma 3: Parasitic form with odor, cause of banana wilt.
Forma 4: Parasitic form without odor.
Synonym *Fusarium cubense* var. *inodoratum* Brandes.

This viewpoint touches a weak point in *Fusarium* taxonomy, as it reveals the difficulties encountered in separating border-line varieties from related species in the section *Elegans.* It is, therefore, only to be regarded as a working hypothesis, which possibly would lead to a considerable simplification of the system.

GROWTH ON VARIOUS MEDIA

The growth characters on various media are similar to those discussed under *Fusarium oxysporum*. No benzolic odor is produced on rice by *Fusarium oxysporum* var. *nicotianae*.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 18 days old; conidia from mycelium and pionnotes:

Conidia—

0-septate, 33 per cent, 11 by 3.5 (5 to 14 by 2.25 to 3.5) μ.
1-septate, 17 per cent, 20 by 3.75 (14 to 23 by 3.5 to 4) μ.
2-septate, 4 per cent, 25 by 3.5 (17 to 27 by 3.5) μ.
3-septate, 45 per cent, 39 by 4 (21 to 46 by 3.5 to 5) μ.
4-septate, 1 per cent, 58 by 4.25 (41 to 59 by 3.5 to 5) μ.

Hard potato agar; culture 26 days old; conidia from mycelium and pionnotes:

Conidia—

0-septate, 1 per cent, 10 by 3.5 μ.
1-septate, 11 per cent, 15 by 3.5 (14 to 18 by 3.25 to 4) μ.
2-septate, 4 per cent, 22 by 3.5 μ.
3-septate, 40 per cent, 34 by 4 (29 to 41 by 3.5 to 4.5) μ.
4-septate, 7 per cent, 34 by 3.75 (33 to 34 by 3.5 to 4) μ.
5-septate, 28 per cent, 51 by 4.25 (45 to 56 by 3.5 to 5) μ.
6-septate, 2 per cent, 55 by 5 (41 to 55 by 4.5 to 5.5) μ.
7-septate, 4 per cent, 56 by 5 (50 to 59 by 4.5 to 5.5) μ.
8-septate, 3 per cent, 60 by 5.5 (58 to 64 by 5.5) μ.
9-septate.
10-septate, rare, 72 by 5.5 μ.

Hard potato agar; culture 39 days old; conidia from sporodochia and pionnotes:

Conidia—

0-septate, 34 per cent, 7 by 2.75 (5 to 11 by 2.25 to 3.5) μ.
1-septate, 3 per cent, 14 by 3.5 (14 to 16 by 3.25 to 3.5) μ.
2-septate, 2 per cent, 19 by 3.5 μ.
3-septate, 52 per cent, 32 by 4 (28 to 38 by 4 to 4.25) μ.
4-septate, 5 per cent, 35 by 4 (34 to 35 by 4) μ.
5-septate, 4 per cent, 38 by 4 (32 to 44 by 4) μ.

Green bean pod; culture 16 days old; conidia from mycelium and pionnotes:

Conidia—

0-septate, 24 per cent, 9 by 3 (5 to 17 by 2 to 4.5) μ.
1-septate, 8 per cent, 17 by 3 (14 to 18 by 2.75 to 3.5) μ.
2-septate, 6 per cent, 24 by 3.5 (23 to 27 by 3 to 4) μ.
3-septate, 61 per cent, 33 by 4 (25 to 45 by 3.25 to 4.5) μ.
4-septate, 1 per cent, 40 by 4.5 μ.

Potato-tuber plug; culture 20 days old; conidia from pionnotes:

Conidia—

3-septate, 75 per cent, 36 by 3.5 (30 to 42 by 3 to 4) μ.
4-septate, 22 per cent, 49 by 3.25 (46 to 51 by 3.25 to 3.5) μ.
5-septate, 3 per cent, 50 by 3.25 μ.

Melilotus; culture 24 days old; conidia from sporodochia:
Conidia—
3-septate, 29 by 4 (24 to 35 by 3.5 to 4.5) μ (short conidia type).
3-septate, 38 by 3.5 (35 to 42 by 3 to 4) μ (long conidia type).
4- to 5-septate, 42 by 3.5 (42 by 3.5 to 3.75) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia—
0-septate, 18 per cent, 7 by 2.75 (5 to 17 by 2.25 to 4.5) μ.
1-septate, 8 per cent, 16 by 3.25 (14 to 23 by 2.75 to 4) μ
2-septate, 3 per cent, 24 by 3.5 (17 to 27 by 3 to 4) μ.
3-septate, 55 per cent, 36 by 4 (21 to 46 by 3.25 to 5) μ.
4-septate, 7 per cent, 42 by 4.25 (33 to 59 by 3.5 to 5) μ.
5-septate, 7 per cent, 44 by 4 (32 to 56 by 3.25 to 5) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Hard potato agar; culture 100 days old:
Chlamydospores, both mycelial and conidial—
0-septate, conidial, 83 per cent, 5.5 to 12 by 4 to 7.25 μ.
1-septate, conidial, 17 per cent, 9 to 18 by 4.5 to 5.25 μ.
0-septate, mycelial, 94 per cent, 5 to 12 by 5 to 9 μ.
1-septate, mycelial, 6 per cent, 9 to 16 by 6 to 8 μ.

FUSARIUM CUBENSE Erwin F. Smith. Plate 2, figs. 6 and 7; Plate 3, figs. 1 to 6; Plate 4, figs. 1 and 5; text fig. 31.

Fusarium cubense SMITH, Science N. S. 36 (1910) 754, 755; BRANDES, Phytopath. 9 (1919) 339–389; WOLLENWEBER, Angew. Bot. Zeit. für Erforsch. der Nutzpfl. 4 (1922) 7–11; Fus. Aut. Del. suppl. (1924) figs. 623–624.

Microconidia gradually attenuate toward the apex, end cell constricted, sickle-shaped, pedicellate, broader in the middle and generally more distinctly curved toward the apex, 3- (4 or 5-) septate, typically 3-septate, 35 by 4 (17 to 51 by 3 to 4.5) μ; also 2- to 5-septate, 2- and 4-septate being commoner, 5-septate rare; 4-septate, 32 to 53 by 3.5 to 5.4 μ; 5-septate, 40 to 57 by 3.5 to 3.75 μ; sporodochia and pionnotes present; microconidia ovoid or elongate, 0- or 1-septate, mostly 0-septate, 5 to 17 by 2.25 to 4.5 μ; 1-septate, 13 to 26 by 3.25 to 4 μ; 2-septate, 18 to 28 by 3.5 to 4.5 μ; frequently produced in abundance with absence of macroconidia on young cultures; chlamydospores abundant in old cultures, in mycelium (intercalary and terminal), in conidia, 0- or 1-septate, 4 to 9 (12) μ in diameter, often catenulate, 0-septate, 4.5 to 9 by 4 to 6.25 μ; 1-septate, 9 to 12 by 4.5 to 7.25 μ. Strong benzolic odor on rice.

As with *F. oxysporum* var. *nicotianae* (see footnote 9, page 192), two types of spores may be produced, long and narrow from pionnotes, and short and wide from mycelium and older sporodochia. The most general spore type is the short and wide. *Fusarium cubense* and the organism described here as *F. oxysporum* var. *nicotianae* are very closely related, and one might best be included as a form of the other. *Fusarium cubense* differs from *F. oxysporum* var. *nicotianae* in producing

FIG. 31. *Fusarium cubense* Erwin F. Smith; *a*, conidia, long, rarer type, from pionnotes of 16-day-old hard potato-agar culture; *b*, conidia, typical, shorter type, from sporodochia of 14-day-old *Melilotus*-stem culture; *c*, conidia, typical, from pionnotes of 22-day-old *Melilotus*-stem culture; *d*, conidia, typical, from sporodochia of 2-month-old hard potato-agar culture; *e*, chlamydospores from conidia and mycelium of 22-day-old hard potato-agar culture; *f*, conidiophore, portion, from pionnotes of 19-day-old banana-peel culture.

a strong benzolic odor on rice, in the general lack of production of sporodochia and pionnotes, and in the production of smaller and fewer sclerotia on hard potato agar and media in general (Plate 3, figs. 2, 7, and 8). The form designated as *F. oxysporum* var. *nicotianae*, according to present investigations,(7) is not parasitic on the banana (*Musa sapientium* Linnæus). The similarity of the organisms from a morphological standpoint indicates that there may be wild saprophytic soil forms of known pathogenic species. Because of the close relationship established for these two strains it is evident that inoculation experiments are necessary to permit accurate differentiation of the

wilt-producing organisms. It would be interesting to determine whether or not the organisms here designated as *F. oxysporum* var. *nicotianae* and the other wilt-producing forms will actually produce disease in their respective hosts.

Habitat.—Vascular parasite causing wilt of banana (*Musa sapientium* Linnæus).(4, 7) The organism also develops on the outer cut surfaces of diseased banana plants, in sporodochia on the surface of diseased banana leaves, occasionally on banana débris, and in the soil of diseased plantations. Tela and Trujillo, Honduras, Central America (*Reinking R 3 and 15*).

Fusarium cubense is prevalent in the soil of diseased banana plantations. Twelve per cent of the soil isolations in diseased banana plantations contained this species.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—The aërial mycelium at first is extremely fine, fluffy, cottony white, and from 2 to 4 mm in height. When 9 days old it is white or may be white and seashell pink at the base and top. Sometimes a patch of soft bluish violet is evident about the point of transfer. Sporodochia or a pionnotes may or may not be produced. Typically they are formed, and are salmon buff, light ochraceous salmon, pale pinkish buff, or pinkish buff. Sometimes concentric rings of sporodochia or pionnotes masses are formed about the point of transfer into the mycelium. Warm buff or cream color, but generally dusky green-blue,(2) deep delft blue, dark delft blue, or cadet gray sclerotia or sclerotial plectenchymata may be developed at this age or somewhat earlier. They are at first formed at the base of the slant on the sides as small bodies in a row. The culture, up to the twenty-fifth day, usually retains its white or seashell pink with the addition of a pale ochraceous salmon or chamois ring at the top and base. The mycelial mass at this age generally becomes more or less matted. At 40 days old it is frequently cartridge buff and ivory yellow or cream buff and is matted and leathery toward the bottom of the slant. Niagara green or terre-verte stromatic folds may develop at the base. When sporodochia or a pionnotes have not developed well, a salmon buff or pinkish buff film may form over the agar slant, especially at the base adjoining the glass. As the culture becomes older the mycelium remains cartridge buff, usually with light buff, pale ochraceous buff, or pale pinkish buff above and below at the edges on the glass. Soft bluish violet may be

present on the agar about the point of transfer. At the age of 90 days and older the mycelial mass usually is flattened, sometimes papery, with the characteristic coloration described above. Over the slant on old typical cultures may be present the light ochraceous salmon, pale ochraceous buff, warm buff, or pinkish buff sporodochial and pionnotal masses. Generally on ordinary cultures, only the mycelial mass without spore bodies is present. In small wartlike heaps, more prevalent toward the base and edge of growth, are the dusky bluish green, dusky green-blue,(2) but generally deep delft blue or dark delft blue sclerotia. On potato-agar plates 12 days old is produced a fine fluffy, medium dense, downy, aërial mycelium that is white with an indication of pale pinkish buff. A light ochraceous salmon pionnotes may be present; when developed the mycelial growth may be zonate.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old are characterized by fine, dense, cottony, pale cinnamon pink, seashell pink, salmon color mycelium. Flesh ocher may be present in places. Bluish slate black sclerotia or stromatic bodies, 0.5 to 1 mm in diameter, may be present here and there. The mycelium in the substratum is seashell pink, salmon buff, or bluish slate black.

Oat agar.—Cultures 1 month old have a fine, dense, cottony white, pale cinnamon pink, and salmon buff mycelium, possibly with spots of bluish slate black and petunia violet at the base of the slant. An Indian lake stroma usually is produced over the agar. Light buff, dusky dull bluish green, and bluish slate black sclerotia, 1 mm in diameter, are developed at the base. Sporodochia and pionnotes masses may or may not be present.

Rice.—The aërial mycelium at first is fine, cottony white, but in two weeks becomes dense above and cameo pink. On the sides it varies from thulite pink, spinel pink, to spinel red. Sporodochia and pionnotes masses are usually produced. Wartlike to cauliflowerlike sclerotia, ranging from 0.5 to 1 mm in diameter, with a light buff interior covered with white, cameo pink, thulite pink, spinel pink, or spinel red mycelium, are developed. A strong benzolic odor is usually evident at this age. As the culture grows older, the colors become darker due to a change from an acid to an alkaline modification. The mycelium at 60 days old may be spinel red, rosolane purple, Schoenfeld's purple, and sometimes Indian lake. The top mycelium is matted, and that on the sides is leathery. The benzolic odor at this age may not be so pronounced.

Potato-tuber plug.—The aërial mycelium is at first extremely fine, fluffy, and cottony white. As the culture grows older the mycelial mass becomes very dense, matted, and at 3 weeks may show a seashell pink or salmon buff in places, especially where it touches the glass. At this age sclerotia, 0.5 to 1 mm in diameter, may have developed, being formed in small wartlike heaps, the young warm buff, the older dark terre-verte, dusky bluish green, or dark delft blue; when 80 days old, the mycelial mass usually has changed to cartridge buff and has become matted and thick leathery. Some cultures become light buff, cream color, warm buff, pale pinkish buff, or ivory yellow, and may have spots of yellow ocher in places, especially on the glass. Spots of seashell pink, pinkish buff, pale bluish lavender, dusky bluish green, or deep delft blue may appear in places; the base is frequently honey yellow and leathery. The sclerotia remain the same. Sporodochia and pionnotes masses may be developed.

Melilotus stem.—Cultures 12 days old are characterized by a fine, fluffy, downy, aërial mycelium that is white, seashell pink and, in places where it touches the glass, clay color or Dresden brown. A pinkish cinnamon pionnotes made up of a mass of small sporodochia may be present on the stem. Dusky green-blue(2) or deep delft blue, small sclerotia are often produced.

Alnus stem.—One-month-old growth is scant and seashell pink or pale pinkish buff. Sporodochia may be produced over the twig. When young they are salmon buff, when older chestnut brown.

Mature corn stalk.—At first the aërial mycelium that is developed is white, very scant, but fine and cottony. In cultures 50 days old the mycelium is still scant, white in places, usually seashell pink with pale ochraceous buff, light buff, or cream color in places. The older cultures may be in places madder violet or seldom terre-verte, dusky dull violet,(1, 2) or dark slate violet. Plectenchymic bodies of the same color may be present in places. Cinnamon buff sclerotia are rarely developed. Pale flesh color or cream buff sporodochia or pionnotes masses may be developed.

Banana peel.—In young cultures only a scant, fine, cottony white mycelium is produced. In older cultures, up to 100 days old, the mycelium is pale orange yellow, pale ochraceous buff, light ochraceous buff, pale pinkish buff, pinkish buff, cinnamon buff, cartridge buff, or cream buff, especially on top and where

it touches the glass. Very scant production of mycelium or none at all may be characteristic of the older cultures. Small sporodochia or a pionnotes frequently may develop by the twentieth day. They are light ochraceous salmon, ochraceous buff, light pinkish cinnamon, cinnamon, or honey yellow. In older cultures, up to 100 days old, they usually are pinkish cinnamon or cinnamon. At 20 days of age, a few small wartlike sclerotia may have developed in places over the banana peel. They vary from Saccardo's umber, dusky bluish green, deep delft blue, bister, tawny olive, dusky drab, grayish olive, pale olive gray, blackish green-gray, to gray (pale gull gray), or black.

Banana fruit flesh.—At first a medium growth of fine, cottony, white mycelium is produced. When older it is matted and a pale pinkish cinnamon on top. Wartlike bone brown sclerotia may be formed within three weeks. An orange vinaceous dense pionnotes growth may develop over the surface of older cultures.

Green bean pod.—Young cultures are characterized by an extremely fine, fluffy, and cottony white mycelium. It gradually changes to cartridge buff or cream color, often with a pale pinkish buff coloration above on top. At the age of 15 days sporodochia or a pionnotes may have developed. They are light ochraceous salmon, light ochraceous buff, light pinkish cinnamon, cinnamon, and pinkish buff. As the growth becomes older, up to 100 days of age, the mycelial mass usually is matted, sometimes flat and more or less papery, and is white or cartridge buff with the extremities seashell pink to pale pinkish buff with yellow ocher or clay color where it touches the glass. The sporodochia and pionnotes masses may have changed to cinnamon, mikado brown, or Verona brown. Warm buff, cinnamon buff, dark delft blue, blackish brown,(3) or grayish olive wartlike heaps of sclerotia, from 0.5 to 1 mm in diameter, may be present.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 40 days old; conidia from sporodochia (short conidia type):

Conidia—

0-septate, 13 per cent, 9 by 3 (6 to 10 by 2.25 to 3.5) μ.
1-septate, 9 per cent, 17 by 3.5 (14 to 20 by 3.25 to 4) μ.
2-septate, 3 per cent, 23 by 4 (20 to 28 by 3.5 to 4.5) μ.
3-septate, 74 per cent, 32 by 4 (23 to 44 by 3.5 to 4.5) μ.
4-septate, 1 per cent, 47 by 4.5 μ.

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Green bean pod; culture 30 days old; conidia from sporodochia (short conidia type):

Conidia—

0-septate, 5 per cent, 12 by 3 (10 to 14 by 2.75 to 3.5) μ.
1-septate, 7 per cent, 20 by 3.5 (15 to 26 by 3.25 to 3.75) μ.
2-septate, 3 per cent, 20 by 4 μ.
3-septate, 83 per cent, 32 by 4 (27 to 36 by 3.5 to 4.5) μ.
4-septate, 2 per cent, 37 by 4 μ.

Banana peel; culture 50 days old; conidia from sporodochia (short conidia type):

Conidia—

0-septate, 20 per cent, 9 by 2.75 (8 to 10 by 2.75) μ.
1-septate, 6 per cent, 16 by 2.75 μ.
2-septate, 3 per cent, 20 by 3.5 μ.
3-septate, 71 per cent, 30 by 4.25 (24 to 35 by 4 to 4.5) μ.

Hard potato agar; culture 16 days old; conidia from pionnotes (long conidia type):

Conidia—

3-septate, 59 per cent, 43 by 3.5 (34 to 51 by 3 to 3.75) μ.
4-septate, 36 per cent, 45 by 3.5 (40 to 50 by 3.5 to 3.75) μ.
5-septate, 5 per cent, 48 by 3.5 (40 to 57 by 3.5 to 3.75) μ.

Melilotus stem; culture 15 days old; conidia from pionnotes and sporodochia:

Conidia—

3-septate, 98 per cent, 34 by 4.25 (27 to 41 by 3.5 to 4.5) μ.
4-septate, 2 per cent, 41 by 4.5 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

0-septate, 19 per cent, 10 by 3 (5 to 17 by 2.25 to 4.5) μ.
1-septate, 6 per cent, 18 by 3.5 (13 to 26 by 3.25 to 4) μ.
2-septate, 2 per cent, 23 by 4 (18 to 28 by 3.5 to 4.5) μ.
3-septate, 67 per cent, 35 by 4 (17 to 51 by 3 to 4.5) μ.
4-septate, 5 per cent, 43 by 4 (32 to 53 by 3.5 to 4.5) μ.
5-septate, 1 per cent, 48 by 3.5 (40 to 57 by 3.5 to 3.75) μ.

MEASUREMENTS OF CHLAMYDOSPORES ON DIFFERENT MEDIA

Hard potato agar; culture 3 months old:

Chlamydospores—

0-septate, in conidia, 75 per cent, 7 by 6 (5 to 10 by 4.5 to 8) μ.
1-septate, in conidia, 25 per cent, 12 by 4.5 (10 to 18 by 4.5 to 5.5) μ.
0-septate, in mycelium, 100 per cent, 7.5 by 7.5 (5.5 to 9 by 5.5 to 9) μ.

Green bean pod; culture 77 days old:

Chlamydospores—

0-septate, in conidia, 100 per cent, 6.5 by 6.5 (4.5 to 9 by 4.5 to 8) μ.

Banana peel; culture 3 months old:

Chlamydospores—

0-septate, in conidia, 87 per cent, 7 by 5 (4.5 to 9 by 4 to 6.25) μ.

1-septate, in conidia, 13 per cent, 10 by 5 (9 to 12 by 4.5 to 7.25) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Chlamydospores:

0-septate, in conidia, 83 per cent, 7 by 6 (4.5 to 10 by 4 to 8) μ.

1-septate, in conidia, 18 per cent, 12 by 5 (9 to 18 by 4.5 to 7.25) μ.

0-septate in mycelium, 100 per cent, 7.5 by 7.5 (5.5 to 9 by 5.5 to 9) μ.

FUSARIUM AURANTIACUM (Link) Saccardo emend. Wollenweber. Text fig. 32.

Fusarium aurantiacum WOLLENWEBER, Jahresber. d. Ver. f. Angew. Bot. 14 (1916) 2, 127; Ann. Myc. 15 (1917) 24.

Conidia moderately sickle-shaped, pedicellate, end cell constricted, in masses, Isabella color or dirty orange, 3-septate, 35 by 4.25 (30 to 40 by 3.5 to 4.5) μ; 4- or 5-septate, 36 per cent; 5-septate, 43 by 4.25 (40 to 45 by 4 to 4.5) μ; ocher sporodochia; blue sclerotia in abundance; chlamydospores present; odor absent.

FIG. 32. *Fusarium aurantiacum* (Link) Saccardo emend. Wollenweber; *a*, conidia from sporodochia of 26-day-old potato-tuber plug culture; *b*, conidia from sporodochia and mycelium of 12-day-old hard potato-agar culture; *c*, chlamydospores from mycelium of 1-month-old hard potato-agar culture.

Differs from *F. oxysporum* var. *nicotianae* and *F. cubense* in having larger and broader spores and more abundant sclerotia.

Habitat.—In soil. Trujillo, Honduras, Central America (*Reinking R 204*). On roots of diseased sugar cane (*Saccharum officinarum* Linnæus). Jamaica (*Hansford 7, R 227*).

Fusarium aurantiacum produces a fruit rot of Cucurbitaceæ and a foot disease of cereals in Europe.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 2 months old are characterized by a medium dense, matted, cartridge buff mycelium. Light buff and chiefly dusky bluish green sclerotia in wartlike heaps, 1 to 2 mm in diameter, are present. Light ochraceous buff sporodochia may be produced over some of the sclerotia.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a medium dense, purplish vinaceous, aërial mycelium. Deep delft blue sclerotia are usually present. Pale cinnamon pink sporodochia may be found in with the mycelium. The mycelium in the substratum is warm blackish brown.

Oat agar.—Cultures 1 month old have a medium dense, matted, pale ochraceous salmon, with a little pinkish vinaceous mycelium over the slant. Large masses of wartlike heaps of sclerotia are produced. They are covered with a pale ochraceous salmon mycelium or are dusky dull bluish green or blackish brown,(3) and measure from 1 to 4 mm in diameter. Large masses of ochraceous salmon sporodochia are produced. They may run together, producing a pionnotes.

Rice.—Cultures 23 days old are characterized by a variety of colors, starting at the top and ranging down from thulite pink, spinel pink, and spinel red. Large wartlike masses of sclerotia are produced.

Potato-tuber plug.—Growth 23 days old is similar to that described on oat agar, except for fewer sporodochia.

Melilotus stem.—Cultures 2 months old have a scant, cinnamon buff mycelium that is matted on top and thin over the sides of the stem. Large masses of deep delft blue sclerotia, measuring 0.5 to 3 mm in diameter, are produced all over the stem. Heaped, vinaceous cinnamon and pinkish cinnamon sporodochia that run together and form a pionnotes are also present in places on the sides of the stem.

Green bean pod.—Cultures 80 days old have a medium, thin matted, cartridge buff and cream buff mycelium. Small cinnamon buff sclerotia and Verona brown sporodochia are produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 27 days old; conidia from sporodochia:

Conidia—

0-septate, 12 per cent, 6 by 2.25 (4 to 8 by 1.5 to 2.75) μ.
1-septate, 4 per cent, 10 by 2.75 (9 to 11 by 2.75) μ.
2-septate, 2 per cent, 27 by 4 μ.
3-septate, 73 per cent, 33 by 4.25 (26 to 38 by 3.5 to 4.5) μ.
4-septate, 9 per cent, 36 by 4.25 (33 to 39 by 3.5 to 4.5) μ.

Hard potato agar; culture 66 days old; conidia from sporodochia:
Conidia—
0-septate, 4 per cent, 5 by 2.75 μ.
1-septate.
2-septate.
3-septate, 88 per cent, 34 by 4.5 (31 to 40 by 4 to 5)μ.
4-septate, 5 per cent, 34 by 4.75 (32 to 35 by 4.5 to 5) μ.
5-septate, 3 per cent, 47 by 4.25 (36 to 59 by 4 to 4.5) μ.
Green bean pod; culture 11 days old; conidia from sporodochia:
Conidia—
0-septate, 5 per cent, 6 by 3 (5 to 7 by 2.75 to 3.25) μ.
1-septate, 2 per cent, 14 by 2.75 μ.
2-septate, 2 per cent, 19 by 3.5 μ.
3-septate, 85 per cent, 31 by 4.25 (23 to 36 by 3.5 to 4.5) μ.
4-septate, 6 per cent, 36 by 4.5 (33 to 39 by 4.5) μ.
Potato-tuber plug; culture 26 days old; conidia from sporodochia:
Conidia—
3-septate, 73 per cent, 35 by 3.5 (27 to 44 by 3 to 4) μ.
4-septate, 24 per cent, 41 by 3.5 (33 to 50 by 3 to 4) μ.
5-septate, 3 per cent, 47 by 3.75 (42 to 52 by 3.5 to 4) μ.
Melilotus stem; culture 1 month old; conidia from sporodochia:
Conidia—
3-septate, 88 per cent, 35 by 3.5 (27 to 42 by 3 to 4) μ.
4-septate, 12 per cent, 47 by 4 (47 to 48 by 4) μ.
Oat agar; culture 21 days old; conidia from sporodochia:
Conidia—
3-septate, 60 per cent.
4-septate, 30 per cent.
5-septate, 10 per cent.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 77 per cent, 34 by 4 (23 to 44 by 3 to 5) μ.
4-septate, 15 per cent, 41 by 4.25 (26 to 50 by 3 to 5) μ.
5-septate, 3 per cent, 47 by 4 (36 to 59 by 3.5 to 4.5) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Green bean pod; culture 16 days old:
Chlamydospores—
0-septate, mycelium, 80 per cent (6.25 to 7 by 6.25 to 10) μ.
1-septate, mycelium, 20 per cent (7 to 8 by 11 to 14) μ.

FUSARIUM LUTULATUM Sherbakoff. Text fig. 33.

Fusarium lutulatum SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 209–213; WOLLENWEBER, Ann. Myc. 15 (1917) 24.

Sherbakoff's description of *F. lutulatum* is as follows:

Macroconidia gradually attenuate toward the apex, usually distinctly pedicellate and uniformly curved throughout, without stronger curvature near apex, typically 3-septate, 34 by 4 (28

to 38 by 3.7 to 4.5) μ, also 2- to 5-septate; from small to medium sporodochia (up to 2 mm in diameter), often converging into pseudopionnotes, aërial mycelium, when present, short (mostly from 1 to 2 mm high), white, often, especially on agars in plate cultures, absent; color of conidia from nearly white (on aërial mycelium in the form of coarse powder) to dark vinaceous purple; sometimes on potato-stem plug, from one to a few large sporodochia (2 mm in diameter) of a bright orange color produced; substratum from colorless to that of the conidial mass; small bluish black sclerotia (0.5 mm in diameter) sometimes produced, and then in great numbers all over the substratum (on potato-tuber plug); zonation of colony very faint or none on neutral agars in plate cultures.

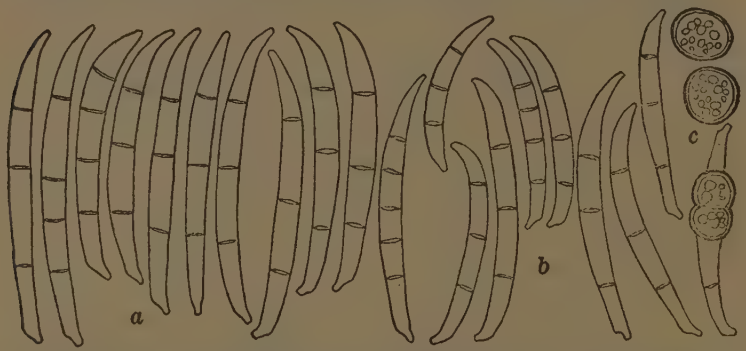

FIG. 33. *Fusarium lutulatum* Sherbakoff; *a*, conidia from pionnotes of 5-day-old hard potato-agar culture; *b*, conidia from pionnotes of 3-month-old hard potato-agar culture; *c*, chlamydospores from 3-month-old hard potato-agar culture.

To the diagnosis should be added that *F. lutulatum* has a strong benzolic odor on rice.

Habitat.—In vascular bundles of pseudostem of wilt-diseased banana plant (*Musa sapientium* Linnæus). Tela, Honduras, Central America (*Reinking R 22*).

Fusarium lutulatum Sherbakoff was placed as a synonym under *F. hyperoxysporum* Wollenweber in Fusaria autographice delineata, fig. 380, because of the presence of blue sclerotia and a perfect pionnotes, by which they differ from *F. oxysporum*. However, *F. hyperoxysporum* has a felty, luxuriant mycelial growth covering a thick plectenchymatic sheet (stroma) that is dark violet on potato agar. Large blue sclerotial bodies in

groups are common. The aërial mycelium of *F. lutulatum*, when present, is short (1 to 2 mm high) and often, especially on agars in plate cultures, it is absent. A violet color of the stroma also is produced on potato agar. Sometimes small blue sclerotial bodies are produced in large numbers. *Fusarium lutulatum* has in general more resemblance to the series *Pallens* of the subsection *Oxysporum* of *Elegans*, while *F. hyperoxysporum* is more related to *F. oxysporum* and belongs to the series *Cyanostroma* of the subsection *Oxysporum* of *Elegans*. Therefore, it seems better to separate both species and retain *F. lutulatum* as a legitimate species.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 21 days old are characterized by scant white aërial mycelium to none. A cinnamon buff pionnotes is produced all over the slant.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have no aërial mycelium, but have a Congo pink pionnotes mass over the plate.

Oat agar.—Cultures 21 days old have no aërial mycelium. A light vinaceous cinnamon and vinaceous cinnamon pionnotal growth is present over the slants. Cultures 1 month old may have minute, blackish brown(1) sclerotia at the base.

Rice.—Cultures 21 days old are characterized by the absence of aërial mycelium and the presence of a salmon color pionnotes over the rice. A strong benzolic odor is produced.

Potato-tuber plug.—Cultures 21 days old have a medium scant, matted, pale ochraceous salmon and light ochraceous salmon mycelium over the potato plug. A light ochraceous salmon and ochraceous salmon pionnotes is present over the tuber.

Green bean pod.—Cultures 2 months old have a thin, medium scant, white, cartridge buff, seashell pink, and salmon buff mycelium. A light ochraceous salmon and Verona brown pionnotes is present on the mycelium in places. Minute dark delft blue sclerotia may be produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 24 days old; conidia from pionnotes:
Conidia—
3-septate, 93 per cent, 38 by 3.75 (34 to 42 by 3.25 to 4) μ.
4-septate, 4 per cent, 40 by 3.75 (35 to 48 by 3.75) μ.
5-septate, 3 per cent, 40 by 3.5 μ.

Hard potato agar; culture 1 month old; conidia from pionnotes:
Conidia—
0-septate, 6 per cent, 9 by 2.75 (6 to 11 by 2.75) μ.
1-septate, 4 per cent, 13 by 3.5 (13 to 14 by 3.25 to 3.75) μ.
2-septate, 1 per cent, 19 by 3.75 (18 to 21 by 3.5 to 4) μ.
3-septate, 86 per cent, 30 by 4 (20 to 42 by 3.5 to 4.5) μ.
4-septate, 3 per cent, 43 by 4.25 (38 to 49 by 4 to 4.5) μ.
Green bean pod; culture 20 days old; conidia from pionnotes:
Conidia—
0-septate, 9 per cent, 8 by 3.25 (5 to 19 by 2.75 to 4) μ.
1-septate, 3 per cent, 20 by 3.75 (14 to 26 by 2.75 to 4.5) μ.
2-septate, 2 per cent, 23 by 3.75 (20 to 26 by 3.5 to 4) μ.
3-septate, 85 per cent, 30 by 4.25 (12 to 35 by 3.5 to 4.5) μ.
4-septate.
5-septate, 1 per cent, 44 by 4.5 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 88 per cent, 33 by 4 (22 to 42 by 3.25 to 4.5) μ.
4-septate, 2 per cent, 42 by 4 (35 to 49 by 3.75 to 4.5) μ.
5-septate, 1 per cent, 42 by 4 (40 to 44 by 3.5 to 4.5) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Green bean pod; culture 77 days old:
Chlamydospores—
0-septate, conidial, 100 per cent, 6.5 by 6.5 (4.5 to 7.25 by 4.5 to 9) μ.

XIV. Section MARTIELLA Wollenweber

Including section *Martiella* Wollenweber and *Pseudomartiella* Wollenweber

Martiella WOLLENWEBER, Phytopath. 3 (1913) 30; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 244; WOLLENWEBER, Ber. der Deutsch. Bot. Gesell. 35 (1918) 738; WOLLENWEBER, SHERBAKOFF, REINKING, JOHANN, and BAILEY, Journ. Agr. Research 30 (1925) 841.

Macroconidia dorsiventral, spindle- to sickle-shaped, apex more or less curved, or rounded, base more or less subpedicellate; microconidia oval to oblong, mostly 0-septate; sporodochia and pionnotes present, white, pale ocher or golden; stroma greenish to blue or almost black; chlamydospores terminal, intercalary, 1-celled, 2-celled, catenulate or in heaps. Imperfect stage of the ascomycete *Hypomyces*, section *Pseudomartiella*.

FUSARIUM SOLANI (Martius pro parte) Appel and Wollenweber var. MINUS Wollenweber. Text fig. 34.

Fusarium solani minus WOLLENWEBER, Ann. Myc. 15 (1917) 55.

Macroconidia 3-septate, 27 to 33 by 4.25 to 5 μ; chlamydospores terminal, intercalary, singly, catenulate or in heaps, sometimes

rugulose, 7 to 8 μ in diameter. For other characters see *F. solani.*

Habitat.—On mature leaves of standing banana plant, on cut end of banana rhizome (*Musa sapientium* Linnæus), on rotted stem of living plant (*Impatiens sultani*), and in soil. Tela, Honduras, Central America (*Reinking R 130*). On roots of diseased sugar cane (*Saccharum officinarum* Linnæus) and in soil. Jamaica (*Hansford 6 and 19, R 226 and 239*).

The organism is rather common on decaying parts of banana that have fallen to the ground.

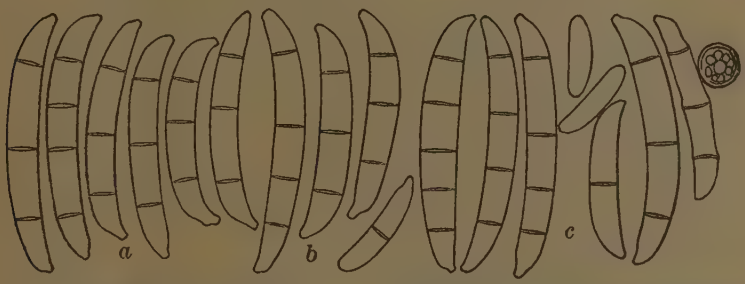

FIG. 84. *Fusarium solani* (Martius p. p.) Appel and Wollenweber var. *minus* Wollenweber; *a*, conidia from pionnotes of 25-day-old hard potato-agar culture; *b*, conidia from pionnotes of 15-day-old oatmeal-agar culture; *c*, conidia and chlamydospore from pionnotes of 16-day-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Growth on various media is similar to that discussed under *F. solani.*

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 12 days old; conidia from sporodochia:
Conidia—
0-septate, 3 per cent, 8 by 3.25 (7 to 10 by 3.25) μ.
1-septate, 4 per cent, 18 by 4.75 (13 to 23 by 4.5 to 5) μ.
2-septate, 2 per cent, 27 by 4.5 (23 to 31 by 4.5) μ.
3-septate, 88 per cent, 33 by 5 (25 to 41 by 5) μ.
4-septate, 2 per cent, 37 by 5.25 (36 to 39 by 5.25) μ.
5-septate, 1 per cent, 39 by 5.5 μ.

Hard potato agar; culture 30 days old; conidia from sporodochia:
Conidia—
0-septate, 6 per cent, 13 by 4 (9 to 17 by 3.25 to 4.5) μ.
1-septate, 11 per cent, 19 by 4.5 (14 to 23 by 4 to 5) μ.
2-septate, 8 per cent, 23 by 4.75 (20 to 27 by 4.5 to 5) μ.
3-septate, 72 per cent, 32 by 4.75 (27 to 38 by 4.5 to 5) μ.
4-septate, 3 per cent, 39 by 5.5 (40 to 42 by 5 to 6) μ.

Green bean pod; culture 11 days old; conidia from sporodochia:
Conidia—
0-septate, 3 per cent, 11 by 3.25 μ.
1-septate, 3 per cent, 14 by 5 μ.
2-septate, 2 per cent, 23 by 4.5 μ.
3-septate, 81 per cent, 30 by 5.25 (26 to 34 by 5 to 5.5) μ.
4 septate, 11 per cent, 39 by 5.5 (35 to 40 by 5 to 6) μ.
Green bean pod; culture 30 days old; conidia from sporodochia:
Conidia—
0-septate, 6 per cent, 13 by 4 (10 to 17 by 3.5 to 5) μ.
1-septate, 8 per cent, 22 by 4.5 (19 to 25 by 4 to 5) μ.
2-septate, 9 per cent, 26 by 4.75 (21 to 28 by 4.5 to 5) μ.
3-septate, 75 per cent, 32 by 5 (27 to 37 by 5) μ.
4-septate, 2 per cent, 37 by 5.25 (36 to 37 by 5 to 5.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 79 per cent, 32 by 5 (25 to 41 by 4.5 to 5.5) μ.
4-septate, 5 per cent, 38 by 5.25 (35 to 42 by 5 to 6) μ.
5-septate, 1 per cent, 39 by 5.5 μ.

MEASUREMENTS OF CHLAMYDOSPORES

Hard potato agar; 12 days old:
Chlamydospores—
0-septate, mycelium, 100 per cent, 7.25 by 7.25 μ.
1-septate, mycelium.

FUSARIUM SOLANI (Martius pro parte) Appel and Wollenweber var. SUFFUSCUM Sherbakoff. Text fig. 35.

Fusarium solani suffuscum SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 254–255; WOLLENWEBER, Ann. Myc. 15 (1917) 25.

Sherbakoff's description is as follows:

Differs from *F. solani* and *F. solani* var. *cyanum* mainly by typically well-developed, uniform, fine, aërial mycelium, with a mass of chlamydospores at maturity which gives it a pale brownish tint; by sparse conidial production on aërial mycelium; and by the fact that sporodochia are usually few and distant from one another.

Habitat.—On diseased cacao pod (*Theobroma cacao* Linnæus). Panama, Central America (*Dunlap 135, R 114*). In the soil. Tela, Honduras, Central America (*Reinking R 199*).

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 14 days old are characterized by a medium scant, cottony, tufted, ivory white mycelium that may have a chamois ring at the sides and base of the slant. Cultures 1 to 3 months old have a medium dense and matted, cartridge buff, cream buff, and light buff mycelium. Frequently

no sporodochia are produced. When found in the older cultures they are chamois or cinnamon.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a scant aërial mycelium to none. The mycelium in the substratum is cinnamon buff.

Oat agar.—Cultures 1 month old have a dense, white, and cartridge buff mycelium with edges of wood brown. Generally no fruiting bodies are produced.

FIG. 35. *Fusarium solani* (Martius p. p.) Appel and Wollenweber var. *suffuscum* Sherbakoff; *a*, conidia from mycelium of 2-month-old hard potato-agar culture; *b*, conidia from mycelium of 1-month-old *Melilotus*-stem culture; *c*, chlamydospores from 2-month-old hard potato-agar culture; *d*, conidiophore from mycelium of 1-month-old green bean-pod culture.

Rice.—Cultures 20 days old have a dense, matted, white and amber yellow mycelium. It may be leathery at the base where it touches the glass. Old cultures, 2 months of age, have a thin, matted, cartridge buff and chamois mycelium that may also be leathery in places.

Potato-tuber plug.—Cultures 25 days old are characterized by a dense, matted, white, light buff, and cream color mycelium. Cultures 2.5 months old have a thin, matted, and leathery mycelium that is cream color, pinkish buff, and cinnamon.

Melilotus stem.—Cultures 2 months old have a scant, white, aërial mycelium.

Alnus stem.—Cultures 1 month old are characterized by a scant, white and pale pinkish buff mycelium.

Green bean pod.—Cultures 45 days old have a thin, matted, cartridge buff, light buff, and warm buff mycelium.

Banana peel.—Cultures 25 days old have a medium scant, white and cinnamon brown mycelium.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 14 days old; conidia from small sporodochia:
Conidia—
0-septate, 3 per cent, 8 by 2.75 (7 to 10 by 2.75) μ.
1-septate, 36 per cent, 19 by 4 (16 to 23 by 3.5 to 4.5) μ.
2-septate, 28 per cent, 23 by 4.5 (23 to 24 by 4.5 to 5) μ.
3-septate, 33 per cent, 26 by 4.5 (23 to 28 by 4.5 to 5) μ.
Green bean pod; culture 31 days old; conidia from mycelium:
Conidia—
0-septate, 89 per cent, 7 by 3.75 (6 to 13 by 2.75 to 5) μ.
1-septate, 4 per cent, 12 by 3.75 (10 to 14 by 3.25 to 4.5) μ.
2-septate.
3-septate, 7 per cent, 29 by 4.75 (24 to 33 by 4.5 to 5) μ.
4-septate, rare, 32 by 5 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 15 per cent, 28 by 4.5 (23 to 33 by 4.5 to 5) μ.
4-septate, rare, 32 by 5 μ.

MEASUREMENTS OF CHLAMYDOSPORES

Hard potato agar; culture 2 months old:
Chlamydospores—
0-septate, in mycelium, 6 to 10 by 6 to 10 μ.
1-septate, in mycelium, 11 to 15 by 6 to 7 μ.

FUSARIUM SOLANI (Martius pro parte) Appel and Wollenweber. Text. fig. 36.

Fusarium solani APPEL and WOLLENWEBER, Arb. K. Biol. Anst. Land- u. Forstw. 8 (1910) 65–78; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 251–253; CARPENTER, Journ. Agr. Research 5 (1915) 204; WOLLENWEBER, Ann. Myc. 15 (1917) 25.

Macroconidia scattered in mycelium or in false heads, in sporodochia or pionnotes, spindle-shaped or slightly curved, typically broader in upper half of length, rounded to slightly constricted apex, slightly pedicellate, or not at all, 1- to 5-septate, typically 3-septate, 30 to 40 by 5 to 6 (25 to 45 by 4.5 to 6.5) μ; fewer 2- and 4-septate; 1-septate, 15 by 4 μ; 5-septate, 42 to 48 by 6 μ; conidia mass brownish white, in older cultures light brown and sometimes with green or greenish blue; plectenchymata sometimes greenish blue in older cultures, and white or brownish white in younger; chlamydospores terminal, intercalary, in mycelium and conidia, 1-celled, spherical or pear-shaped, 8.5 by 8 μ, 2-celled, 12 by 7.75 μ, less seldom in chains or heaps, smooth, sometimes definitely rugose.

Fusarium solani has a broad type of conidia.

Habitat.—In bark rot of Washington navel orange (*Citrus sinensis* Osbeck) and in the soil. Tela and Trujillo, Honduras, Central America (*Reinking R 101*).

Fusarium solani is generally regarded as a saprophyte, but under exceptional circumstances may become a weak wound parasite.

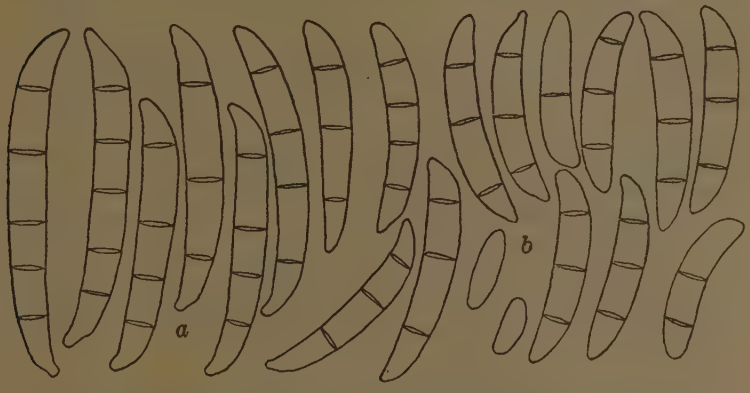

FIG. 86. *Fusarium solani* (Martius p. p.) Appel and Wollenweber; *a*, conidia from pionnotes of 24-day-old hard potato-agar culture; *b*, conidia from pionnotes of 3-month-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 1 month old are characterized by a loose, coarse, woolly, granular, white to cartridge buff mycelium. Pionnotes masses are produced abundantly in large heaps and are cream buff and olive buff when young, and when older are citrine drab, often with slight indication of French green. Older cultures, 3 months old, have a cartridge buff and deep olive buff mycelium and the pionnotes masses and sporodochia are frequently glaucous green or Montpellier green. One-month-old potato agar plates have a loose, coarse, woolly, granular, white to cartridge buff aërial mycelium over the plate. Few cream color tuberculate sporodochia are produced here and there. There is a slight indication of zonation. A plectenchymic mass that is porcelain green may be produced frequently in the center of the plate.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a white to cartridge buff aërial mycelium, and that in the substratum is cinnamon buff and clay color. A dusky dull bluish green pionnotes may be present in the center of the plate.

Oat agar.—Cultures 1 month old are characterized by a medium coarse to fine woolly mycelium that is white to cartridge buff. Sporodochia and pionnotes masses are produced in large groups over the slant. They are cartridge buff and olive buff.

Rice.—Cultures 1 month old have a scant mycelium that is light buff, buckthorn brown, Hessian brown, with yellow ocher in places. Pionnotes masses and sporodochia are produced. They are pinkish buff, seashell pink, and light russet, vinaceous, and occasionally with pale glaucous green. The rice is colored flesh pink, brick red, and dragon's blood red. On the addition of a 10 per cent potassium hydroxide solution, the reds change to dusky violet.

Potato-tuber plug.—Cultures 1 month old have a loose, coarse, woolly, granular mycelium that is white to cartridge buff, often with dark terre-verte at base. Large masses of sporodochia that run together, forming a pionnotes, are usually produced. They are mostly cartridge buff, pale olive buff, and glaucous. Some are deep lichen green and Niagara green. Small plectenchymic sclerotialike masses, 1 to 3 mm in diameter, may sometimes be produced. They are blackish brown.(3)

Melilotus stem.—One-month-old growth is characterized by a loose, coarse, woolly, granular, white to cartridge buff mycelium. Cream color pionnotes masses and sporodochia are present over the stem in small and large heaps. They may be glaucous green in places. Blackish brown(3) small sclerotia may be produced.

Alnus stem.—Cultures 1 month old have a scant, white to cartridge buff aërial mycelium. Small, pale pinkish buff sporodochia are produced over the stem from the lenticels. They may be in columns, from 1 to 2 mm long.

Green bean pod.—Cultures 2 months old are characterized by having a medium thick, matted, cartridge buff and ivory buff mycelium. Large, spherical, pinkish buff, chamois, deep olive buff, citrine drab, deep olive, and deep bluish gray-green sporodochia are produced.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 35 days old; conidia from sporodochia:

Conidia—

0-septate, 3 per cent, 13 by 4.5 (11 to 14 by 3.25 to 5) μ.
1-septate, 6 per cent, 17 by 4.75 (13 to 19 by 4 to 5.5) μ.
2-septate, 6 per cent, 27 by 5.25 (22 to 30 by 5 to 5.5) μ.
3-septate, 68 per cent, 33 by 5.25 (24 to 51 by 5 to 5.25) μ.
4-septate, 16 per cent, 45 by 5.5 (41 to 49 by 5.25 to 6) μ.
5-septate, 1 per cent, 50 by 6.25 μ.

Green bean pod; culture 11 days old; conidia from sporodochia:
Conidia—
0-septate, 3 per cent, 11 by 4.5 (10 to 13 by 3.25 to 5.5) μ.
1-septate, 4 per cent, 19 by 4.75 (15 to 23 by 4 to 5.5) μ.
2-septate, 1 per cent, 24 by 5.5 (23 to 25 by 5 to 6) μ.
3-septate, 84 per cent, 36 by 5.25 (25 to 45 by 5 to 5.5) μ.
4-septate, 8 per cent, 41 by 5.5 (37 to 45 by 5.25 to 6) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 76 per cent, 35 by 5.5 (24 to 51 by 5 to 6.25) μ.
4-septate, 12 per cent, 43 by 5.5 (37 to 49 by 5.25 to 6) μ.
5-septate, 1 per cent, 50 by 6.25 μ.

FIG. 37. *Fusarium alluviale* Wollenweber and Reinking; *a*, conidia from pionnotes of 25-day-old hard potato-agar culture; *b*, conidia from sporodochia of 21-day-old *Melilotus*-stem culture; *c*, conidium from pionnotes.

FUSARIUM ALLUVIALE Wollenweber and Reinking. Plate 2, fig. 8; text fig. 37.

Fusarium alluviale WOLLENWEBER and REINKING, Phytopath. 15 (March, 1925) 167.

Stroma erumpent, rugose, greenish blue; conidia dorsiventral, spindle- to sickle-shaped, top cell beak-shaped, basal cell slightly pedicellate, in sporodochia, in pionnotes or scattered, in masses from white to chestnut brown; 3-septate, 29 to 34 by 4.25 to 5.25 (25 to 44 by 4 to 6.25) μ; seldom 4-septate, 32 to 43 by 4 to 6 μ; in aërial mycelium smaller conidia also present, 0-septate, 9 to 14 by 3 to 4.5 μ, and 1-septate, 15 to 25 by 4 to 5.25 μ; chlamydospores terminal, intercalary, sometimes spiny, in mycelium and in conidia, mostly unicellular, 6 to 11 μ in diameter. Strong odor produced on various culture media.

Habitat.—In alluvial soil. Trujillo, Honduras, Central America (*Reinking R 188*).

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a thin matted, powdery, cartridge buff and cinnamon buff my-

celium, sometimes with spots of lichen green or glaucous blue in places and buckthorn brown at the base. Cultures 1 month old have a matted, fine felty, white to cartridge buff mycelium that may be in zones at the base of the slant. Pionnotes masses are produced often in zones about the point of transfer, and they are cream buff. Older cultures, up to 3 months of age, show no change in the mycelium, but the heaped and scattered sporodochia are chamois, honey yellow, and deep olive. On one-month-old potato-agar plates a scant, usually distinctly zonate, cartridge buff aërial mycelium is produced. A cream buff and glaucous green pionnotes may be present.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a scant, white and pinkish buff, slightly zonate, aërial mycelium. The mycelium in the substratum is sayal brown.

Oat agar.—Cultures 1 month old are characterized by a medium dense, medium fine woolly, white and cartridge buff mycelium. Large wartlike heaps of sclerotia, 1 to 4 mm in diameter, are usually present. They may be covered with pionnotes or sporodochia. The interior of the sclerotia is buckthorn brown, while the exterior is bluish slate black. The sporodochia and pionnotes masses are deep olive buff. A characteristic, very strong odor is produced.

Rice.—Cultures 20 days old have a scant aërial mycelium that is citron yellow, light perilla purple, in places sorghum brown, and dusky greenish blue and petunia violet in places. Cream color or vinaceous buff sporodochia and pionnotes masses may be produced. Cultures 1 month old have a scant white aërial mycelium, usually with a characteristic black ring on the top of the rice. The mycelium on the glass may be burnt lake. The rice itself is colored brick red and dragon's blood red. Small, cartridge buff sporodochia are usually present. On addition of a 10 per cent solution of potassium hydroxide the liquid changes to dark vinaceous. Cultures 2 months old have a leathery mycelium and may have light buff or vivid purple wartlike sclerotia. The mycelium may have changed in places to perilla purple, dark vinaceous purple, or dark slate purple. The strong characteristic odor is produced.

Potato-tuber plug.—Cultures 20 days old have a felty, white, cream color, and in patches dark greenish olive mycelium. Few small ivory yellow sclerotia may be developed. Cream buff sporodochia and pionnotes masses are present. Growth 1 month old is short, fine cottony, matted, and thin felty in places. It is

white or buckthorn brown, deep lichen green, and rejane green in places. Small, bone brown sclerotia may be present.

Melilotus stem.—Cultures 1 month old are characterized by a medium scant, fine fluffy mycelium that is pale grayish vinaceous to russet vinaceous with drops of dark vinaceous brown water here and there. The liquid at the base of the tube turns dark vinaceous brown. Tilleul buff and pale olive buff sporodochia and pionnotes masses are produced on the mycelium that develops over the liquid and on the sides of the stem.

Alnus stem.—Cultures 1 month old have a scant white, aërial mycelium. Small, pale pinkish buff and pinkish buff sporodochia and pionnotes masses are developed here and there over the twig.

Green bean pod.—Cultures 1 to 2 months old have a medium thin, matted, cartridge buff, pinkish buff, and cinnamon buff mycelium over the bean. Masses of honey yellow and pinkish cinnamon sporodochia and pionnotes are usually present.

Banana peel.—Cultures 1 month old have a scant, cartridge buff mycelium with small pinkish buff and cinnamon buff sporodochia over the peel.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 10 days old; conidia from sporodochia:
Conidia—
0-septate, 34 per cent, 11 by 4 (9 to 13 by 3.25 to 5.25) μ.
1-septate, 28 per cent, 19 by 4.25 (15 to 28 by 3.5 to 5) μ.
2-septate, 4 per cent, 28 by 5 (27 to 30 by 5) μ.
3-septate, 33 per cent, 34 by 5.5 (25 to 39 by 5.25 to 6) μ.
4-septate, 1 per cent, 43 by 4 μ.

Oat agar; culture 2 weeks old; conidia from sporodochia:
Conidia—
3-septate, 75 per cent, 35 by 4.25 (30 to 40 by 4 to 5) μ.
4-septate, 24 per cent.

Green bean pod; culture 9 days old; conidia from sporodochia:
Conidia—
0-septate, 27 per cent, 12 by 3.75 (7 to 15 by 3.25 to 4.5) μ.
1-septate, 23 per cent, 20 by 4.75 (16 to 25 by 3.5 to 5) μ.
2-septate, 5 per cent, 25 by 5 (23 to 30 by 4.5 to 5.25) μ.
3-septate, 44 per cent, 44 by 5.25 (24 to 39 by 5 to 6) μ.
4-septate, 1 per cent, 38 by 5.75 (38 to 41 by 5.5 to 6) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
0-septate, 20 per cent, 11 by 3.75 (7 to 15 by 3.25 to 5.25) μ.
1-septate, 17 per cent, 19 by 4.5 (15 to 28 by 3.5 to 5) μ.
2-septate, 3 per cent, 26 by 5 (23 to 30 by 4.5 to 5.25) μ.
3-septate, 50 per cent, 38 by 5 (24 to 40 by 4 to 6) μ.
4-septate, 9 per cent, 40 by 5 (38 to 43 by 4 to 6) μ.

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MEASUREMENTS OF CHLAMYDOSPORES ON DIFFERENT MEDIA

Chlamydospores:

0-septate, conidia, 6.5 to 8 by 6.5 to 8 μ.

0-septate, mycelium, 6 to 11 by 6 to 11 μ.

FUSARIUM MARTII Appel and Wollenweber var. MINUS Sherbakoff. Plate 4, figs. 2, 3, 4, and 6; text fig. 38.

Fusarium martii minus SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 249–250; WOLLENWEBER, Ann. Myc. 15 (1917) 26.

Sherbakoff's description is as follows:

Differs from *F. martii* and *F. martii* var. *viride* by having smaller, 3-septate conidia, 36.7 by 4.8 (30 to 44 by 4.55 to 5.1) μ, usually prominent development of plectenchymic, wartlike stromata, and fewer and larger sporodochia. Color of substratum, on potato agar, rich in glucose, from light gray to drab and dark olive buff, with a fuscous-colored spot at the point of inoculation.

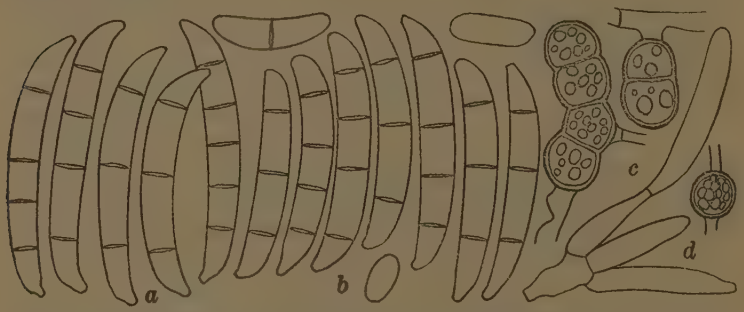

FIG. 38. *Fusarium martii* Appel and Wollenweber var. *minus* Sherbakoff; *a*, conidia from pionnotes of 22-day-old hard potato-agar culture; *b*, conidia from pionnotes of 3-month-old hard potato-agar culture; *c*, chlamydospores from 3-month-old hard potato-agar culture; *d*, conidiophore from sporodochia of 11-day-old green bean-pod culture.

Habitat.—On decaying banana bunch, on cut surfaces of pseudostem of banana, in interior of rhizome of banana (*Musa sapientium* Linnæus) after having been cut and allowed to stand for a day; in crown rot of citrus (*Citrus aurantifolia* Swingle) and in the air and soil. Tela and Trujillo, Honduras, Central America (*Reinking R 65*).

Fusarium martii var. *minus* is very common in the soil throughout banana plantations. Forty-four per cent of all soil isolations made, comprising three hundred sixty-five, were found to contain this variety. It is also rather common on decaying banana parts.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a medium dense, coarse, cottony, and in places tufted mycelium that is ivory yellow, cartridge buff, frequently with concentric rings of thick and thin mycelium or rings of terre-verte. Pinkish buff, cinnamon buff, and ochraceous buff sporodochia and heaped pionnotes masses are produced in places over slant, especially at the base. Cultures 1 month old have the same loose, medium coarse, woolly and granular, white to cartridge buff mycelium. The pionnotes may have changed to glaucous green, light terre-verte, bluish gray-green, or citrine drab. Older cultures, 3 months of age, have a scant, coarse, cottony white, cartridge buff, and cream buff mycelium with yellowish glaucous on the glass. The sporodochia and pionnotes masses are chamois, honey yellow, cream buff, mustard yellow, olive buff, pale glaucous green, and deep glaucous green. Frequently they are in concentric rings about the point of transfer. Mummy brown sclerotia may be present. On potato-agar plates 1 month old a loose, medium coarse, granular, woolly, white to cartridge buff mycelium is produced, a dusky green-blue(2) stroma may be present and the mycelium may be zonate, cream buff, chamois, deep olive buff, or sometimes glaucous green; pionnotes masses and sporodochia are present here and there on the plate.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a short, woolly, white, cartridge buff, and iron gray aërial mycelium, that in the substratum is clay color, tawny olive, and iron gray. An olivaceous black(3) pionnotes may be produced.

Oat agar.—Cultures 1 month old have a medium coarse, woolly, white and cartridge buff mycelium; a dusky dull green stroma may be present in places. Small and large sporodochia forming large heaps of pionnotes masses are present; they are pale pinkish buff and pinkish buff.

Rice.—Cultures 20 days old have a medium scant, matted mycelium that is white, cartridge buff, and chestnut brown. The rice is changed to shrimp pink or seashell pink. Small, bone brown sclerotia may be developed; warm buff, pinkish buff, salmon buff, flesh color, pale olive buff, deep Corinthian red, or vinaceous rufous sporodochia and pionnotes masses are produced. Cultures 1 month old are characterized by scant, white, aërial mycelium. On the rice it is Prussian red and ocher red, possibly in a ring. The rice itself is Etruscan red. The pion-

notes spore mass is pale pinkish buff, light pinkish cinnamon, or hydrangea pink. In older cultures, 2 months old, the mycelium changes to colonial buff, cameo brown, chocolate, or chestnut brown. The sporodochia and pionnotes masses have also become walnut brown and in some cases with orange vinaceous, apricot buff, light vinaceous cinnamon, or occasionally pale Niagara green. Upon addition of a 10 per cent solution of potassium hydroxide the plectenchymic mass and the liquid turn dusky violet, which is the alkaline color modification.

Potato-tuber plug.—Cultures 1 month old are characterized by a loose, medium coarse, granular, woolly, white to cartridge buff mycelium. It may also be leathery, and Saccardo's umber or Saccardo's brown in places. Spots of pistachio green and stromatic masses of dusky dull bluish green and deep delft blue may also be present. Small, spherical, Saccardo's umber or olive buff sclerotia may develop. The greater part of the plug may be covered with sporodochia and pionnotes masses that are usually warm buff, pinkish buff, olive buff, and tawny olive, but sometimes porcelain green, dark porcelain green, and dusky green-blue.(2) Older cultures are much the same as to the mycelium, but usually have more deep olive buff, Niagara green, terre-verte, glaucous green, and snuff brown sporodochia and pionnotes masses. The sclerotia may also be indigo blue.

Melilotus stem.—Cultures 1 month old have a loose, medium coarse, granular, woolly, white and cartridge buff mycelium. Mainly a pionnotes is produced over the stem with a few sporodochia. They are cream color and light buff, occasionally deep glaucous green. Blackish brown(3) sclerotia may develop.

Mature corn stalk.—Cultures 1 month old have a scant white to cream color mycelium. Bone brown sclerotia may be present. Warm buff and cinnamon buff, often with pale glaucous green, sporodochia and pionnotes masses are produced.

Banana peel.—Cultures 2 months old have a scant pinkish buff and cinnamon buff mycelium with cinnamon buff, olive buff, deep olive buff, and lichen green, light terre-verte, or Gobelin blue sporodochia and pionnotes masses.

Green bean pod.—Cultures 16 days old have a medium scant to thick, cartridge buff and cream buff mycelium. At this age the sporodochia and pionnotes masses are chamois and honey yellow. Three-month-old cultures have a medium scant, white to cartridge buff or cinnamon buff mycelium. It may be clay

color where it touches the glass. Sporodochia and pionnotes masses are scattered over the bean. They are warm buff, cream buff, cinnamon buff, olive buff, citrine drab, and light porcelain green to glaucous green. Some of the oldest may be mikado brown or Natal brown. Isabella color sclerotia may be present.

Banana fruit flesh.—Cultures 26 days old have a medium thin, matted mycelium that is white, pinkish buff, glaucous blue, and orient blue.

The color characters, especially of the spore masses, may be somewhat variable; that is, under some conditions the green may be present, and then under other conditions the same culture will not produce the green. There are two basic colors in the section *Martiella;* namely, light orange yellow and indigo blue. All other colors present are modifications of these; consequently a variety of colors, from yellow to blue, as pointed out in the above descriptions, can be obtained. The change in the color of the rice may also vary from seashell pink to Etruscan red.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 11 days old; conidia from sporodochia:
Conidia—
0-septate, 7 per cent, 12 by 4.25 (8 to 17 by 3.25 to 5) μ.
1-septate, 11 per cent, 19 by 5 (15 to 26 by 4 to 6) μ.
2-septate, 4 per cent, 27 by 5 (25 to 32 by 4.5 to 6) μ.
3-septate, 72 per cent, 36 by 5.5 (26 to 50 by 4.5 to 6) μ.
4-septate, 5 per cent, 48 by 5.5 (41 to 57 by 5.25 to 6) μ.
5-septate, 1 per cent, 52 by 5.5 (48 to 53 by 5.25 to 6) μ.

Hard potato agar; culture 20 days old; conidia from pionnotes:
Conidia—
3-septate, 71 per cent, 39 by 4.5 (23 to 52 by 3.75 to 5.75) μ.
4-septate, 23 per cent, 43 by 4.75 (31 to 51 by 4.5 to 5) μ.
5-septate, 6 per cent, 40 by 5 (35 to 53 by 4.25 to 5.5) μ.

Green bean pod; culture 11 days old; conidia from pionnotes:
Conidia—
0-septate, 2 per cent, 12 by 4.25 (8 to 14 by 3.25 to 5) μ.
1-septate, 3 per cent, 19 by 5 (16 to 23 by 3.5 to 6) μ.
2-septate, 3 per cent, 26 by 5.25 (22 to 29 by 4 to 5.5) μ.
3-septate, 85 per cent, 34 by 5.25 (22 to 41 by 4.5 to 6) μ.
4-septate, 7 per cent, 37 by 5.25 (32 to 43 by 4.5 to 6) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 76 per cent, 36 by 5 (22 to 52 by 3.75 to 6) μ.
4-septate, 12 per cent, 43 by 5 (32 to 57 by 4.5 to 6) μ.
5-septate, 3 per cent, 46 by 5.25 (35 to 53 by 4.25 to 6) μ.

MEASUREMENTS OF CHLAMYDOSPORES ON DIFFERENT MEDIA

Hard potato agar; culture 2 months old:

Chlamydospores—

0-septate, conidial, 100 per cent, 7.25 by 6.25 (5.5 to 9 by 5.5 to 7.25) μ.

1-septate, conidial.

0-septate, mycelial, 72 per cent, 8.5 by 8.5 (8 to 9 by 8 to 9) μ.

1-septate, mycelial, 18 per cent, 12 by 9 (9 to 9 by 9 to 14) μ.

Rice; culture 70 days old:

Chlamydospores—

0-septate, conidial, 100 per cent, 12 by 6 (10 to 14 by 6 to 6) μ.

1-septate, conidial.

0-septate, mycelial, 91 per cent, 10 by 10 (8 to 12 by 8 to 12) μ.

1-septate, mycelial, 9 per cent, 10 by 10 (8 to 12 by 8 to 12) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Chlamydospores:

0-septate, conidial, 100 per cent, 6 by 9.5 (5.5 to 7.25 by 5.5 to 14) μ.

1-septate, conidial.

0-septate, mycelial, 81 per cent, 9.25 by 9.25 (8 to 12 by 8 to 12) μ.

1-septate, mycelial, 19 per cent, 11 by 9.5 (8 to 14 by 8 to 12) μ.

Terminal and intercalary chlamydospores are produced. When young they are smooth, and when older rugose.

FUSARIUM MARTII Appel and Wollenweber var. VIRIDE Sherbakoff. Plate 5, figs. 5 to 8; text fig. 39.

Fusarium martii viride SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 247–249; WOLLENWEBER, Ann. Myc. 15 (1917) 26.

Sherbakoff's description is as follows:

Differs from *F. martii* by having macroconidia somewhat narrower and usually by a paler color of conidia and substratum; dark blue color of conidial masses not observed. Typical color of conidia in mass, on potato agar rich in glucose, pale smoke gray and substratum pale drab gray.

Habitat.—On rotted roots of citrus (*Citrus aurantifolia* Swingle) and in the soil. Tela and Trujillo, Honduras, Central America (*Reinking R 99*).

Fusarium martii var. *viride* is rather common in the soil, having been found in 3 per cent of the total soil isolations. This fungus is distributed also in Europe on *Solanum*, *Pisum*,

Pirus, and other plants. In England it has been proved to be a wound parasite causing apple-fruit rot in storage.[10]

It is a question whether or not this is a valid variety, as the variation in spore measurements and color characters in *F. martii* var. *minus* would cover the slight differences here observed.

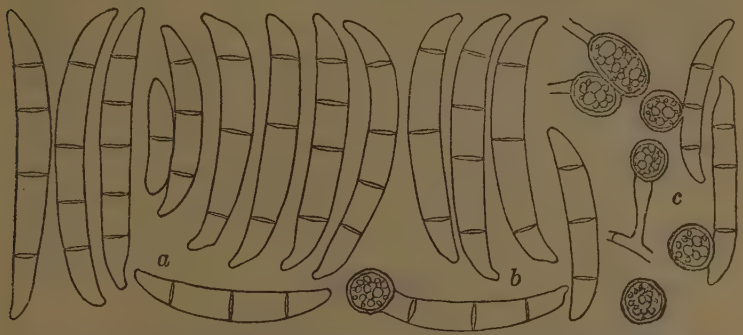

FIG. 39. *Fusarium martii* Appel and Wollenweber var. *viride* Sherbakoff; *a*, conidia from pionnotes of 7-day-old hard potato-agar culture; *b*, conidia from pionnotes of 7-day-old hard potato-agar culture; *c*, chlamydospores from 21-day-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

The growth characters on various media are very similar to those discussed under *F. martii* var. *minus*. The conidial masses may not be quite so dark blue, although this character is variable. The green coloration, especially in zonation, may be more marked in this variety.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 11 days old; conidia from pionnotes:
Conidia—
0-septate, 3 per cent, 12 by 4.25 (8 to 14 by 3.25 to 4.5) μ.
1-septate, 7 per cent, 19 by 4.5 (14 to 23 by 3.5 to 5.25) μ.
2-septate, 1 per cent, 25 by 5.25 (23 to 28 by 5 to 5.5) μ.
3-septate, 85 per cent, 38 by 5.25 (33 to 44 by 5 to 5.5) μ.
4-septate, 3 per cent, 41 by 5.5 (36 to 44 by 5.5) μ.
5-septate, 1 per cent, 41 by 5.5 μ.

Hard potato agar; culture 20 days old; conidia from pionnotes:
Conidia—
0-septate, 1 per cent, 12 by 3.5 (12 to 13 by 3.5 to 3.5) μ.
1-septate, 2 per cent, 19 by 4.75 (16 to 23 by 4.5 to 5) μ.
2-septate, 2 per cent, 23 by 5 μ.
3-septate, 79 per cent, 41 by 5.25 (33 to 48 by 5 to 5.5) μ.
4-septate, 14 per cent, 42 by 5 (35 to 49 by 4.5 to 5.5) μ.
5-septate, 2 per cent, 45 by 5 (39 to 50 by 4.5 to 5.5) μ.

[10] Kidd, M. N., and A. Beaumont, Trans. Brit. Myc. Soc. 10 (1924) 116.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

3-septate, 82 per cent, 40 by 5.25 (33 to 48 by 5 to 5.5) μ.
4-septate, 8 per cent, 42 by 5.25 (35 to 49 by 4.5 to 5.5) μ.
5-septate, 2 per cent, 43 by 5.25 (39 to 50 by 4.5 to 5.5) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Green bean pod; culture 45 days old:

Chlamydospores—

0-septate, conidial, 100 per cent, 7.25 by 6 (5.5 to 9 by 5.5 to 6.25) μ.
1-septate, conidial.
0-septate, mycelial, 88 per cent, 12 by 8 (9 to 14 by 7 to 9) μ.
1-septate, mycelial, 12 per cent, 17 by 9.5 (12 to 22 by 9 to 10) μ.

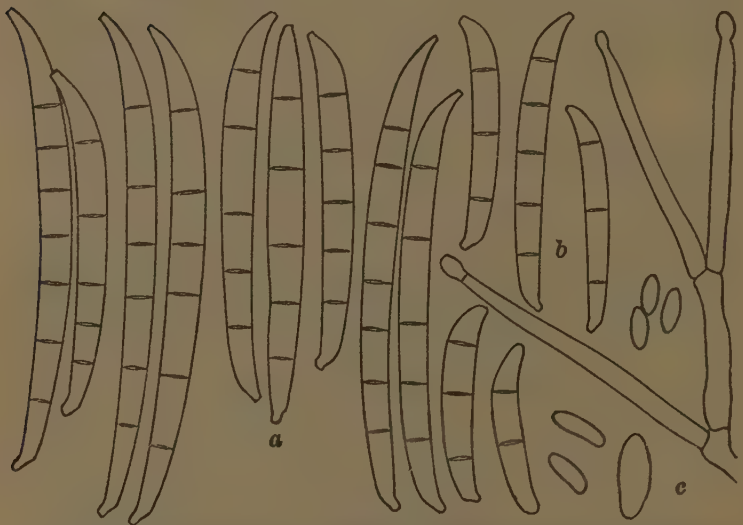

FIG. 40. *Fusarium martii* Appel and Wollenweber; *a*, conidia, typical, from pionnotes of 9-day-old potato-tuber plug culture; *b*, conidia, small type, from pionnotes of 23-day-old hard potato-agar culture; *c*, conidiophore from 8-day-old green bean-pod culture.

FUSARIUM MARTII Appel and Wollenweber. Text fig. 40.

Fusarium martii APPEL and WOLLENWEBER, Arb. Kais. Biol. Anst. f. Land- u. Forstw. 8 (1910) 78–84; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 244–247; WOLLENWEBER, Ann. Myc. 15 (1917) 25–26.

The original diagnosis of the fungus from Irish potatoes gives the following characters:

Conidia scattered in the mycelium, in false heads, or in sporodochia or pionnotes, normal conidia much longer than in

F. solani, straight in the middle or only slightly curved, curve somewhat more pronounced at the ends, especially the apex, dorsal and ventral sides almost parallel, except at the apex; 3- or 4-septate, 44 to 60 by 4.75 to 5.5 (39 to 70 by 4.5 to 6) μ; less frequently 5-septate, 54 to 62 by 4.5 to 5.75 μ; 6-septate, up to 82 by 5 μ; color of conidial masses between brownish white and light brown and, through the mingling of the greenish blue plectenchymata, the pionnotes may assume a gray, bluish gray, or brown to black color; plectenchymatic stroma little or lacking; chlamydospores as in *F. solani*.

Habitat.—On rotted wild fig fruit (*Ficus* sp.) on ground and in the soil. Trujillo and Tela, Honduras, Central America (*Reinking R 91*).

Fusarium martii has been proved to cause apple-fruit rot in England.[11]

GROWTH ON VARIOUS MEDIA

Growth characters on various media are similar to those discussed under *F. martii* var. *minus*.

MEASUREMENTS OF CONIDIA ON VARIOUS MEDIA

Hard potato agar; culture 11 days old; conidia from sporodochia:
Conidia—
0-septate, 4 per cent, 9 by 3.5 (9 to 10 by 3.5) μ.
1-septate, 4 per cent, 22 by 3.75 (21 to 23 by 3.5 to 4) μ.
2-septate, 2 per cent, 29 by 4.5 μ.
3-septate, 70 per cent, 34 by 4.75 (23 to 38 by 4.5 to 5.25) μ.
4-septate, 16 per cent, 37 by 4.75 (36 to 41 by 4.5 to 5) μ.
5-septate, 4 per cent, 41 by 5.25 (41 to 42 by 5 to 5.25) μ.

Potato-tuber plug; culture 9 days old; conidia from pionnotes:
Conidia—
4-septate, 2 per cent, 54 by 4.75 (48 to 60 by 4 to 5.5) μ.
5-septate, 58 per cent, 57 by 5 (50 to 63 by 4.5 to 5.5) μ.
6-septate, 31 per cent, 71 by 4.75 (70 to 73 by 4.5 to 5) μ.
7-septate, 9 per cent, 73 by 4.75 (70 to 76 by 4.5 to 5) μ.

Green bean pod; culture 90 days old; conidia from pionnotes:
Conidia—
0-septate, 19 per cent, 7 by 2.5 (5 to 9 by 2 to 2.75) μ.
1-septate, 2 per cent, 14 by 3.25 (14 to 15 by 3.25 to 3.5) μ.
2-septate.
3-septate, 21 per cent, 31 by 4.5 (21 to 39 by 4 to 5) μ.
4-septate, 26 per cent, 37 by 5.25 (28 to 41 by 4.5 to 6) μ.
5-septate, 32 per cent, 40 by 5.25 (36 to 42 by 5.25 to 5.5) μ.

[11] Kidd, M. N., and A. Beaumont, l. c.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

3-septate, 30 per cent, 33 by 4.5 (21 to 39 by 4 to 5.25) μ.
4-septate, 15 per cent, 43 by 5 (28 to 60 by 4 to 6) μ.
5-septate, 31 per cent, 46 by 5.25 (36 to 63 by 4.5 to 5.5) μ.
6-septate, 10 per cent, 71 by 4.75 (70 to 73 by 4.5 to 5) μ.
7-septate, 3 per cent, 73 by 4.75 (70 to 76 by 4.5 to 5) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Green bean pod; culture 45 days old:

Chlamydospores—

0-septate, conidial, 100 per cent, 7.25 by 5.25 (7.5 to 8 by 4.5 to 6) μ.
1-septate, conidial.
0-septate, mycelial, 83 per cent, 8 by 8 (7 to 9 by 7 to 9) μ.
1-septate, mycelial, 17 per cent, 13 by 9 μ.

FUSARIUM VIRIDE (Lechm.) Wollenweber. Text fig. 41.

Fusarium viride WOLLENWEBER, Ann. Myc. 15 (1917) 26.

Conidia scattered in the mycelium, in false heads, or in sporodochia or pionnotes, normal conidia larger, especially broader, than *F. martii*, slightly curved, curve more pronounced at the ends, subpedicellate, 3- to 5-septate, 30 to 50 by 4.5 to 6 μ; 3-septate, 35 by 5.5 μ; 4-septate, 44 by 5.5 μ; 5-septate, 46 by 5.5 μ; conidial mass cream buff, olive buff, with green; bluish green plectenchymata may be present; chlamydospores smooth, and when older roughened, 9 to 10 μ in diameter.

Habitat.—In soil. Tela, Honduras, Central America (*Reinking R 170*).

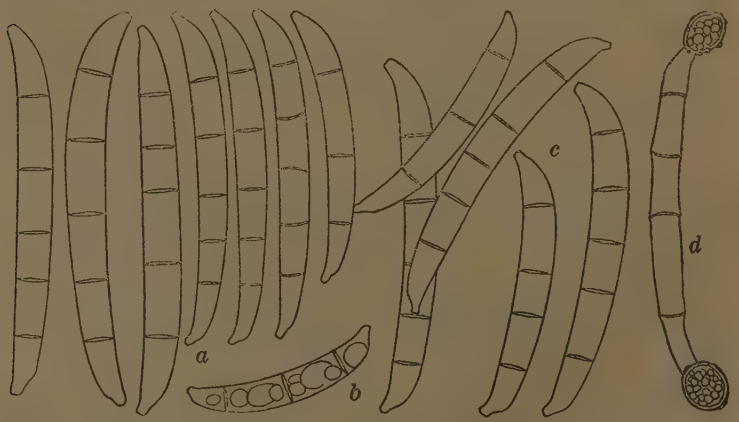

FIG. 41. *Fusarium viride* (Lechm.) Wollenweber; *a*, conidia from pionnotes of 3-month-old hard potato-agar culture; *b*, conidium from sporodochia of 21-day-old *Melilotus*-stem culture; *c*, conidia from pionnotes of 15-day-old potato-tuber plug culture; *d*, chlamydospores in conidium from 3-month-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a medium fine, powdery and woolly mycelium that is white, cartridge buff, ivory yellow, and cinnamon brown. Dusky dull bluish green lines may be present in the agar. Cream buff and pinkish buff sporodochia and pionnotes masses are produced. They may have a touch of Niagara green. Cultures 1 month old are the same, except that the separate pionnotes are in large masses and pinkish buff, deep olive buff, and dark olive buff. The mycelium in cultures 3 months old is cartridge buff with streaks of Saccardo's slate. The agar at the base of the slant may be cinnamon brown. The sporodochia and pionnotes masses are cream buff, Naples yellow with deep lichen green, and glaucous green. Plate cultures 1 month old have a medium fine, powdery, woolly, zonate at the edges, cartridge buff mycelium. A deep olive buff and light porcelain green pionnotes is usually present.

Oat agar.—Cultures 1 month old have a medium scant, aërial, white mycelium. Irregular, large, thick masses of pionnotes are produced over the slant, being made up of sporodochia. They are olive buff with touches of dark terre-verte.

Rice.—Cultures 20 days old have a medium fine, woolly, white, light buff, and Schoenfeld's purple mycelium. Few wartlike, Schoenfeld's purple sclerotia are produced. Some cream color sporodochia are present. The rice is turned coral pink. Cultures 1 month old may have spots of deep Corinthian red, and the rice may have turned Pompeiian red. Older cultures are practically the same, possibly with the addition of a deep vinaceous, leathery mycelium.

Potato-tuber plug.—One-month-old cultures have a scant, medium fine, woolly and matted mycelium that is white, cream color, deep olive, and often with wood brown. Cream buff, dark olive buff, heaped pionnotes masses are present over the plug. They may also have touches of Niagara green and glaucous green. Older cultures may have a Natal brown mycelium in places.

Melilotus stem.—Cultures 1 month old have a medium fine, woolly, white and cartridge buff mycelium. Heaped sporodochia and pionnotes masses are present in places over the stem and on top of the mycelium that is produced over the liquid at the base of the tube. They are cartridge buff and often with dusky green-blue.(2)

Green bean pod.—Cultures 2 months old have a medium thin, matted, ivory yellow mycelium, with large sporodochial masses that are pale olive buff to deep olive buff.

MEASUREMENTS OF CONIDIA ON VARIOUS MEDIA

Hard potato agar; culture 40 days old; conidia from pionnotes:
Conidia—
0-septate, 2 per cent, 13 by 4.5 (12 to 16 by 4.5) μ.
1-septate, 3 per cent, 20 by 4.75 (15 to 23 by 4.5 to 5.5) μ.
2-septate.
3-septate, 41 per cent, 41 by 5.5 (35 to 46 by 5.5) μ.
4-septate, 23 per cent, 45 by 5.5 (37 to 51 by 5.5 to 6) μ.
5-septate, 31 per cent, 50 by 5.5 (45 to 54 by 5.5 to 6) μ.
Green bean pod; culture 15 days old; conidia from pionnotes:
Conidia—
0-septate, 7 per cent, 12 by 4 (9 to 15 by 3.75 to 4) μ.
1-septate, 6 per cent, 20 by 4.75 (14 to 25 by 4.5 to 5) μ.
2-septate, 6 per cent, 28 by 5.25 (28 by 5 to 5.5) μ.
3-septate, 48 per cent, 39 by 5.25 (36 to 43 by 5 to 5.5) μ.
4-septate, 25 per cent, 44 by 5.75 (41 to 52 by 5.5 to 6) μ.
5-septate, 8 per cent, 45 by 6 (42 to 48 by 5.5 to 6.25) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 45 per cent, 40 by 5.25 (35 to 46 by 5 to 5.5) μ.
4-septate, 24 per cent, 45 by 5.5 (37 to 52 by 5.5 to 6) μ.
5-septate, 20 per cent, 48 by 5.75 (42 to 54 by 5.5 to 6.25) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Green bean pod; culture 45 days old:
Chlamydospores—
0-septate in mycelium, 77 per cent, 9.5 by 9.5 (9 to 10 by 9 to 10) μ.
1-septate in mycelium, 23 per cent.

FUSARIUM RADICICOLA Wollenweber. Text fig. 42.

Fusarium radicicola WOLLENWEBER, Journ. Agr. Research 2 (1914) 257–258; SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 257–260; CARPENTER, Journ. Agr. Research 5 (1915) 205; WOLLENWEBER, Ann. Myc. 15 (1917) 26.

Conidia, comparatively slender, spindle- to sickle-shaped, slightly constricted at both ends, apiculate to subpedicellate at the base, normally 3-septate, may occur scattered in sporodochia or pionnotes, averaging 30 to 45 by 3.75 to 5 μ; 25 per cent of the total number may be 4-septate; 5 per cent may be 5-septate and average 40 to 59 by 4 to 5.25 μ; chlamydospores, 7 to 10 μ, agree with those of other species of the section *Martiella*.

Habitat.—In soil. Tela, Honduras, Central America (*Reinking R 165*).

The conidia of *F. radicicola* are narrower than in *F. solani* and are shorter and have fewer septations than in *F. martii.* The plectenchymatic mycelium is olive colored on sterilized potato tuber, with all shades of green and brown. The organisms described by Sherbakoff(9) and later by Carpenter(5) do not agree in all particulars with the original description.

Fusarium radicicola is the cause of a rot of potato tubers and sweet potatoes in the United States.

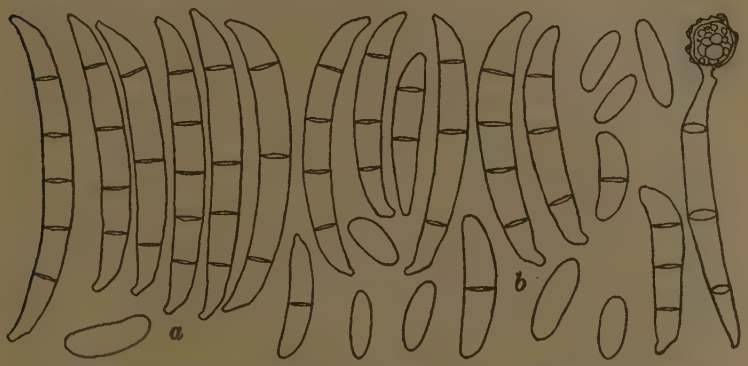

FIG. 42. *Fusarium radicicola* Wollenweber; *a*, conidia from pionnotes of 15-day-old rice culture; *b*, conidia and chlamydospores from pionnotes of 3-month-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a medium coarse, woolly, white and ivory yellow mycelium. The agar is deep slate olive. Warm buff sporodochia are produced in heaps. In cultures 1 month old there is no change in the mycelium, but the sporodochia and pionnotes masses are in heaps, cream buff, olive buff, light terre-verte, and deep lichen green, and are generally in concentric rings over the slant. A characteristic snuff brown and bister ring is present at the edges of the agar on the side and base of the slant. Cultures 3 months old have a scant, woolly, cartridge buff mycelium with a cinnamon buff pionnotes in concentric rings. Characteristically the agar is turned to Natal brown and clove brown. On potato-agar plates, 1 month old, a medium coarse, woolly, white to cartridge buff mycelium is produced with a rather thin and dense cream color and pale olive buff to dark olive buff pionnotes in places under the mycelium.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a short, woolly, tilleul buff, aërial mycelium, while that in the substratum is snuff brown and bister.

Oat agar.—Cultures 1 month old have a medium scant, woolly, white, aërial mycelium. Olive buff and pea green sporodochia in large heaps, gradually forming a pionnotes, are present over the slant. A mummy brown stromatic ring is usually present at the base of the slant.

Rice.—Cultures 19 days old have a medium scant, matted, rhodonite pink mycelium over the rice. Small, bister sclerotia may be present. Cultures 1 month old have a scant, medium fine, woolly, vinaceous pink, avellaneous, and wood brown mycelium. A pale pinkish buff pionnotes is generally produced. The top of the rice substratum is pinkish vinaceous, and lower it is light coral red.

Potato-tuber plug.—Cultures 20 days to 1 month old have a medium coarse, woolly, white, cartridge buff, and light buff mycelium that may also be sepia where it touches the glass. Pionnotes masses made up of sporodochia are present in small heaps. The younger are vinaceous buff, and the older deep olive buff or cinnamon buff, Saccardo's umber, and sepia. The potato cylinder is clove brown. Cultures 80 days old have a pale olive buff and clove brown mycelium that is matted and leathery in places. The pionnotes is olive buff, light terre-verte, and wood brown.

Melilotus stem.—Cultures 1 month old have a medium scant, coarse, woolly, white and cartridge buff mycelium. A thin, cream color and pale olive buff pionnotal growth is produced over the stem.

Green bean pod.—Cultures 1 month old are characterized by a medium dense, cartridge buff, cream buff, and pinkish buff mycelium. Abundant sporodochia and pionnotes masses, 0.5 to 3 mm in diameter and cinnamon buff to cinnamon, are present.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 2 months old; conidia from sporodochia:
Conidia—
0-septate.
1-septate, 4 per cent, 16 by 4.75 (14 to 17 by 4 to 5) μ.
2-septate, 3 per cent, 21 by 4.5 μ.
3-septate, 87 per cent, 32 by 4.5 (26 to 42 by 4 to 5) μ.
4-septate, 4 per cent, 39 by 5 (36 to 44 by 5) μ.
5-septate, 2 per cent, 46 by 4.5 (44 to 49 by 4.5) μ.

Green bean pod; culture 18 days old; conidia from sporodochia:
Conidia—
0-septate, 6 per cent, 11 by 3 (10 to 13 by 2.75 to 3.5) μ.
1-septate, 18 per cent, 15 by 4.25 (14 to 27 by 3.5 to 5) μ.
2-septate, 4 per cent, 24 by 4.5 (22 to 27 by 4.5 to 5) μ.
3-septate, 71 per cent, 32 by 5 (28 to 36 by 4.5 to 5.25) μ.
4-septate, 1 per cent, 41 by 4.5 μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 79 per cent, 32 by 4.75 (26 to 44 by 4.5 to 5.25) μ.
4-septate, 3 per cent, 40 by 4.75 (36 to 44 by 4.5 to 5) μ.
5-septate, 1 per cent, 46 by 4.5 (44 to 49 by 4.5) μ.

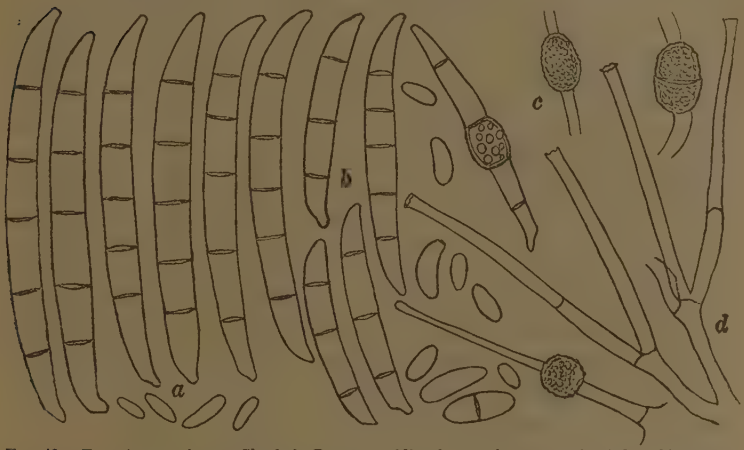

FIG. 43. *Fusarium striatum* Sherbakoff; *a*, conidia from pionnotes of 18-day-old potato-tuber plug culture; *b*, conidia from pionnotes of 16-day-old oatmeal-agar culture; *c*, chlamydospores from 14-day-old potato-tuber plug culture; *d*, conidiophore from mycelium of 23-day-old green bean-pod culture.

FUSARIUM STRIATUM Sherbakoff. Text fig. 43.

Fusarium striatum SHERBAKOFF, N. Y. (Cornell) Agr. Exp. Sta. Memoir No. 6 (1915) 255–257; WOLLENWEBER, Ann. Myc. 15 (1917) 25.

Sherbakoff's description is as follows:

Microconidia, at least on aërial mycelium, always present. Macroconidia of shape and septation intermediate between *F. martii* and *F. solani*, mostly 3-septate, 34.7 by 4.6 (31 to 36 by 4.4 to 5) μ, from colorless to yellowish glaucous and pale turquoise green, in numerous minute sporodochia; sporodochia often converging into a pseudopionnotes; aërial mycelium short (rarely up to 3 millimeters high), typically (on various agars) fine, uniformly from loose to very loose, downy in appearance,

from white to grayish white, substratum, on agars rich in glucose, from pale glaucous green to tawny olive and sepia. Cause of a tuber rot, striate in appearance, of *Solanum tuberosum* Linnæus.

Habitat.—On rotted papaya fruit and rotted tip of living papaya stem (*Carica papaya* Linnæus) (*R 81*) and in the soil. Tela, Honduras, Central America (*Reinking R 81*).

We found a greater percentage of 4- and 5-septate conidia than was reported by Sherbakoff.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by medium scant, coarse, woolly, tufted and powdery in places, cartridge buff, cream buff, and pinkish buff mycelium. Concentric rings of dusky dull bluish green may be present in the agar and also streaks of Saccardo's slate. A buckthorn brown ring is generally produced at the edges of the agar. Ochraceous buff sporodochia may be produced here and there. Cultures 1 month old have the same type of mycelium, except for being a little more dense and having a cinnamon buff pionnotes. Citrine drab streaks may be present in the agar, and the medium may turn sayal brown in places. Potato-agar plate cultures 1 month old have a medium coarse, short woolly, usually radiate and zonate cartridge buff mycelium. Antimony yellow pionnotes masses may be present. A plectenchymic mass of mycelium that is deep glaucous green and light porcelain green is frequently formed.

Potato-agar plate, 5 per cent dextrose.—Growth 1 month old is characterized by a scant, short, woolly, cartridge buff and deep grayish olive mycelium that may be in concentric rings. The mycelium in the substratum is russet vinaceous or dull greenish black.(1)

Oat agar.—Cultures 1 month old have an aërial mycelium that is short, woolly, and white to cartridge buff with patches of stroma that are dark Prussian green and deep delft blue. Cinnamon buff, heaped sporodochia producing pionnotes masses are present.

Rice.—Cultures 20 days old have a scant white mycelium. The rice is colored seashell pink, rufous, and apricot orange. Vinaceous sporodochia are formed in small masses. Cultures 1 month old have a dense, woolly, tufted in places, white, light buff, warm buff, pale grayish vinaceous, Hay's brown, and light seal brown mycelium. A light ochraceous salmon and pale

ochraceous buff pionnotes is produced. The rice substratum is flesh color, vinaceous brown, rufous, and apricot orange.

Potato-tuber plug.—Cultures 18 days old have a medium scant, white to cartridge buff mycelium with masses of sporodochia that are cream buff when young and light terre-verte, dusky green-blue(1) to dark chessylite blue when older. Cultures 1 month old have the same type of mycelium, but the sporodochia and pionnotes usually are tilleul buff, pale olive buff, and terre-verte or dusky bluish green. In older cultures, up to 80 days old, the pionnotes masses may be dark Gobelin blue or dusky dull bluish green.

Melilotus stem.—Growth 1 month old is characterized by a scant, medium fine, woolly, cartridge buff mycelium. Few cream buff, pinkish buff, or citrine drab sporodochia may be present.

Green bean pod.—Cultures 2 months old have a scant, thin, matted, cartridge buff, chamois, pale pinkish buff, pinkish buff, and cinnamon buff mycelium. Cinnamon buff and clay color sclerotia may be present. Cinnamon buff sporodochia are produced sometimes over the sclerotia when present.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 11 days old; conidia from sporodochia:
Conidia—
0-septate, 17 per cent, 9 by 3.5 (6 to 11 by 2 to 5) μ.
1-septate, 6 per cent, 17 by 3.75 (14 to 23 by 3.25 to 5) μ.
2-septate, 3 per cent, 25 by 4.5 (23 to 26 by 4 to 4.5) μ.
3-septate, 43 per cent, 35 by 4.5 (27 to 41 by 4 to 5) μ.
4-septate, 25 per cent, 41 by 4.75 (36 to 46 by 4.5 to 5) μ.
5-septate, 6 per cent, 42 by 5 (41 to 45 by 5 to 5.25) μ.

Potato-tuber plug; culture 18 days old; conidia from pionnotes:
Conidia—
3-septate, 24 per cent, 35 by 4.25 (33 to 37 by 4 to 4.5) μ.
4-septate, 42 per cent, 43 by 4.5 (40 to 47 by 4 to 5) μ.
5-septate, 34 per cent, 53 by 4.5 (46 to 61 by 4 to 5) μ.

Melilotus stem; culture 20 days old; conidia from sporodochia:
Conidia—
3-septate, 30 per cent, 31 by 3.75 (27 to 35 by 3.5 to 3.75) μ.
4-septate, 48 per cent, 41 by 3.75 (35 to 47 by 3.5 to 5) μ.
5-septate, 22 per cent, 43 by 4.25 (30 to 51 by 4 to 4.5) μ.

Green bean pod; culture 9 days old; conidia from sporodochia:
Conidia—
0-septate, 30 per cent, 8 by 3.25 (6 to 9 by 2.75 to 3.5) μ.
1-septate, 2 per cent, 18 by 3.25 (4 to 21 by 3.25) μ.
2-septate, 1 per cent, 23 by 4 μ.
3-septate, 35 per cent, 34 by 4.75 (26 to 38 by 4 to 5) μ.
4-septate, 21 per cent, 38 by 4.75 (35 to 43 by 4.5 to 5) μ.
5-septate, 11 per cent, 43 by 5 (40 to 48 by 5 to 5.25) μ.

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AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:

3-septate, 33 per cent, 34 by 4.25 (26 to 41 by 3.5 to 5) μ.
4-septate, 34 per cent, 41 by 4.5 (35 to 47 by 3.5 to 5) μ.
5-septate, 18 per cent, 45 by 4.75 (30 to 61 by 4 to 5.25) μ.

FUSARIUM JAVANICUM Koorders. Text fig. 44.

Fusarium javanicum KOORDERS, Vern. Koninkl. Akad. Wetensch. Amsterdam II 13 (1907) 247; SACCARDO, Syll. Fung. 22 (1913) 1482; WOLLENWEBER, Ann. Myc. 15 (1917) 26; Ber. der Deutsch. Bot. Gesell. 35 (1918) 742.

Conidia scattered, in sporodochia and pionnotes, 3-, 4- (5-) septate, 43 to 54 by 4.5 to 5 μ; 5-septate, 49 to 54 by 4.5 to 5.25 μ; base subpedicellate, apex cell longer and less curved and

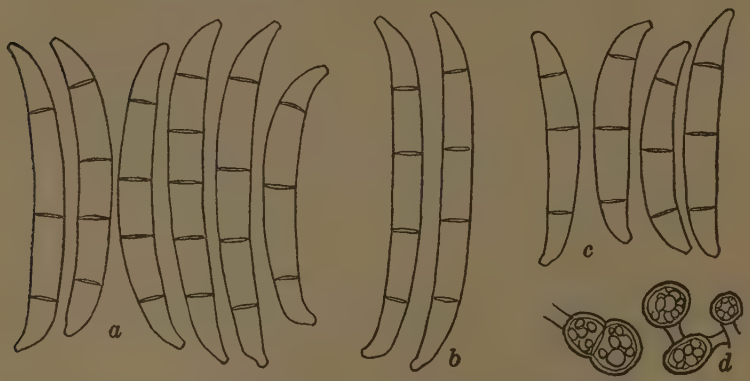

FIG. 44. *Fusarium javanicum* Koorders; *a*, conidia from pionnotes of 24-day-old hard potato-agar culture; *b*, conidia from pionnotes of 17-day-old rice culture; *c*, conidia from sporodochia of 18-day-old *Melilotus*-stem culture; *d*, chlamydospores from 16-day-old hard patato-agar culture.

more pointed than in the preceding species, sometimes acute, approaching sickle-shaped; chlamydospores 1-celled, 2-celled, terminal and intercalary; mycelium white to cartridge buff; conidial masses cream buff, olive ocher, or at times greenish.

Condidia may be the imperfect stage of a *Hypomyces*.

Habitat.—In soil. Tela, Honduras, Central America (*Reinking R 161*).

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a scant, white, cream buff and ivory yellow mycelium, often with a dusky dull bluish green line in the agar and a Dresden brown ring at the base. Concentric rings of cream buff or pinkish buff sporodochia are present. One-month-old growth

has a fine, woolly, matted, but not dense, white and cartridge buff mycelium. Heaped pionnotal masses that are cream buff, cinnamon buff, often with a little glaucous green, are generally formed. The characteristic mummy brown strip is produced at the base and sides of the slant. Cultures 3 months old are very much the same with the pionnotes more of a dark olive buff, and the agar may have turned Hay's brown at the base. Plate cultures 1 month old have a fine, woolly, white and cartridge buff mycelium with a cream buff pionnotes about the point of transfer.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a scant, woolly, cartridge buff, aërial mycelium, while that in the substratum is tawny olive. Citrine drab pionnotes masses may be produced in places.

Oat agar.—Cultures 1 month old are characterized by a medium fine, woolly, white mycelium. A mummy brown ring is usually present at the base of the slant. Cartridge buff, Isabella color, and pale olive buff pionnotes masses made up of sporodochia are present.

Rice.—Cultures 20 days old have a scant, white and pale grayish vinaceous mycelium that may be bone brown and leathery in places. Small, Natal brown and bone brown sclerotia are sometimes formed. Avellaneous sporodochia are produced on top of the rice. One-month-old growth has a fine, woolly, white mycelium with a pale pinkish cinnamon pionnotes. The rice substratum is pale flesh color. Cultures 2 months old have a matted, leathery, cartridge buff, vinaceous drab, and deep purplish vinaceous mycelium, possibly with spots of light seal brown. Vinaceous drab sclerotia may be present. The pionnotes masses are pale grayish vinaceous and tilleul buff. The rice substratum is shrimp pink.

Potato-tuber plug.—Cultures 20 days old are characterized by a scant white, cream color and cinnamon buff mycelium. Ivory yellow, warm buff, pinkish buff, olive buff, and snuff brown pionnotes masses are usually present. Cultures 1 month old have a scant, fine, woolly, white and cinnamon buff mycelium with cream buff, buffy brown, vinaceous russet, and dark olive pionnotes masses composed of sporodochia. Still older cultures, up to 80 days old, have a scant, cartridge buff to cinnamon buff mycelium with honey yellow, cinnamon buff, snuff brown, dark olive buff, Niagara green, and dark terre-verte pionnotes masses.

Melilotus stem.—One-month-old growth has a fine, woolly, cartridge buff mycelium with pinkish buff, streaked with deep

glaucous green sporodochia and heaped pionnotes masses over the stem.

Green bean pod.—Cultures 2 months old have a thin, matted, white, cartridge buff to pinkish buff mycelium with pinkish buff, cinnamon buff, and orange cinnamon sporodochia, 1 to 2 mm in diameter, and pionnotes masses.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 18 days old; conidia from sporodochia:
Conidia—
1-septate, 6 per cent, 20 by 4.75 (19 to 20 by 4.5 to 5) μ.
2-septate, 4 per cent, 23 by 5.25 (17 to 28 by 5 to 5.5) μ.
3-septate, 75 per cent, 42 by 5.5 (39 to 47 by 5 to 6) μ.
4-septate, 15 per cent, 46 by 5.5 (42 to 52 by 5 to 6) μ.
Green bean pod; culture 7 days old; conidia from sporodochia:
Conidia—
0-septate, 2 per cent, 12 by 4 (10 to 15 by 3.25 to 4.5) μ.
1-septate, 10 per cent, 21 by 4.75 (18 to 23 by 4 to 5.25) μ.
2-septate, 3 per cent, 30 by 4.75 (26 to 33 by 4.5 to 6) μ.
3-septate, 82 per cent, 38 by 5.25 (24 to 45 by 4.5 to 5.5) μ.
4-septate, 3 per cent, 43 by 5.25 (40 to 45 by 4.5 to 6) μ.
Hard potato agar; culture 24 days old; conidia from pionnotes:
Conidia—
3-septate, 24 per cent, 41 by 4.75 (37 to 46 by 4.5 to 5) μ.
4-septate, 71 per cent, 49 by 5.25 (45 to 52 by 4.75 to 5.5) μ.
5-septate, 5 per cent, 49 by 5.25 (45 to 52 by 4.75 to 5.5) μ.
Potato tuber plug; culture 16 days old; conidia from pionnotes:
Conidia—
3-septate, 52 per cent, 33 by 4.75 (28 to 38 by 4 to 5.5) μ.
4-septate, 47 per cent.
5-septate, 1 per cent.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 56 per cent, 39 by 5 (24 to 47 by 4 to 6) μ.
4-septate, 34 per cent, 45 by 5.25 (40 to 52 by 4.5 to 6) μ.
5-septate, 2 per cent, 49 by 5.25 (45 to 42 by 4.75 to 5.5) μ.

FUSARIUM THEOBROMAE Appel and Strunk (synonym *Fusarium hevcae* P. Hennings), Text fig. 45.

Fusarium theobromae APPEL and STRUNK, Centr. F. Bact. Par. II, Abt. 11 (1904) 635–637; APPEL and WOLLENWEBER, Arb. Kais. Biol. Anst. f. Land- u. Forstw. 8 (1910) 160, Abb. 90, D1 Taf. 2, 98 f.; WOLLENWEBER and REINKING, Phytopath. 15 (1925) 168.

Stroma plectenchymic, ochraceous white, sometimes olive to greenish blue, aërial mycelium cream white, cæspitose, conidia mostly scattered, more seldom in sporodochia, cream color in masses, elongate, slightly curved, pedicellate 3- to 5-septate; 3-septate, 28 to 46 by 3.5 to 5 μ; 5-septate, 44 to 60 by 4 to 5.5

μ; very rarely 6-septate, 52 to 73 by 4.5 to 5.5 μ; [12] in aërial mycelium also smaller conidia, mostly unicellular ovoid, 6 to 12 by 2.5 to 3.5 μ; chlamydospores globose or pear-shaped, terminal and intercalary, 1-celled, 2-celled, or in clusters, 5 to 8 μ in diameter.

Conidia may be the imperfect stage of a *Hypomyces*.

Habitat.—In soil. Trujillo and Tela, Honduras, Central America (*Reinking R 129*).

Fusarium theobromae has been reported as the cause of pod rot of cacao in various parts of the world.

FIG. 45. *Fusarium theobromae* Appel and Strunk; *a*, conidia from mycelium of 1-month-old oatmeal-agar culture; *b*, conidia from mycelium of 15-day-old hard potato-agar culture; *c*, chlamydospores from 1-month-old hard potato-agar culture.

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a scant, medium fine, cottony, white, ivory yellow, cartridge buff, or cream buff mycelium. A buckthorn brown ring may develop at the base of the slant adjoining the glass. The agar may be deep glaucous green in a few spots. Seldom cream buff, with olive buff, and possibly glaucous green sporodochia are developed. Older cultures, 45 days old, have a scant, cartridge buff and ivory yellow mycelium with a Dresden brown ring at

[12] Conidia, according to the diagnosis of Appel and Strunk, are pluriseptate, 45 to 75 by 5 to 7 μ, while according to Wollenweber, cf. Fus. aut. del. 428, they are 4- to -6 (3- to 7-) septate, 39 to 60 by 4.5 to 5.25 μ.

the base of the slant. Sporodochia when present are terre-verte. On potato agar plates 2 months old a very short, woolly, white to cartridge buff mycelium is found.

Potato-agar plate, 5 per cent dextrose.—Cultures 1 month old have a scant, aërial, light brownish vinaceous mycelium that in the substratum is vinaceous brown.

Oat agar.—Cultures 1 month old have a medium scant, white and cartridge buff aërial mycelium. Generally no fruiting bodies are formed.

Rice.—Cultures 20 days old are characterized by a scant, white and ochraceous tawny mycelium with pallid vinaceous drab in places. The rice is turned buff pink. Small, wartlike, warm buff sclerotia may develop. Cultures 2 months old have a scant mycelium that is cartridge buff, warm buff, and amber yellow and leathery in places, possibly with spots of Verona brown and vinaceous cinnamon. The rice is shrimp pink. Small warm buff sclerotia may be present. Spore bodies are generally not produced.

Potato-tuber plug.—Cultures 21 days old have a thin, furlike, aërial, white mycelium, often with a plectenchymic stroma of dusky green-blue.(2) It may be sepia and leathery where it touches the glass or light yellowish olive. Small, wartlike, Van-dyke brown sclerotia may be present. Older cultures are practically the same, possibly with a change in the plectenchymic stroma to deep delft blue and in the sclerotia to black.

Melilotus stem.—Growth 23 days old is characterized by a medium dense, matted, cartridge buff mycelium over the stem. Generally no fruiting bodies are developed.

Green bean pod.—Cultures 2 months old have a thin, matted, cartridge buff or cream buff mycelium, sometimes with cartridge buff to cream buff sporodochia, and sclerotia that are blackish brown(3) or deep delft blue.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 11 days old; conidia from pionnotes:

Conidia—

0-septate, 2 per cent, 9 by 3.25 (9 to 10 by 3.25) μ.
1-septate, 5 per cent, 18 by 3.75 (14 to 22 by 2.75 to 4.5) μ.
2-septate, 2 per cent, 26 by 4 (25 to 27 by 3.5 to 4.5) μ.
3-septate, 31 per cent, 31 by 4 (24 to 37 by 3.25 to 5) μ.
4-septate, 55 per cent, 44 by 5 (26 to 57 by 3.5 to 5 5) μ.
5-septate, 5 per cent, 47 by 4.5 (31 to 63 by 3.5 to 5.5) μ.
6-septate, rare, 47 by 4 μ.

Hard potato agar; culture 12 days old; conidia from mycelium:
Conidia—
0-septate, 39 per cent.
1-septate, 24 per cent.
2-septate.
3-septate, 25 per cent, 37 by 4.25 (28 to 46 by 4 to 4.5) μ.
4-septate, 9 per cent, 47 by 4.25 (44 to 52 by 4 to 4.5) μ.
5-septate, 3 per cent, 51 by 4.25 (44 to 59 by 4 to 4.5) μ.
6-septate, rare, 66 by 4.75 (60 to 73 by 4.5 to 5) μ.
Oat agar; culture 1 month old; conidia from mycelium:
Conidia—
3-septate, 4 per cent.
4-septate, 33 per cent.
5-septate, 61 per cent, 53 by 5 (47 to 60 by 4.5 to 5.5) μ.
6-septate, 1 per cent.
7-septate, 1 per cent, 52 by 5.5 μ.
Green bean pod; culture 36 days old; conidia from mycelium:
Conidia—
0-septate, 75 per cent, 11 by 3.75 (7 to 12 by 2.75 to 4.5) μ.
1-septate, 19 per cent, 17 by 4.5 (14 to 20 by 4.5) μ.
2-septate, 1 per cent, 23 by 5 μ.
3-septate, 4 per cent, 28 by 4.75 (24 to 32 by 4.5 to 6) μ.
4-septate, 1 per cent, 41 by 4.5 (39 to 41 by 4.5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 20 per cent, 32 by 4.25 (24 to 46 by 3.25 to 6) μ.
4-septate, 22 per cent, 44 by 4.5 (26 to 57 by 3.5 to 6.5) μ.
5-septate, 3 per cent, 50 by 4.5 (31 to 63 by 3.5 to 5.5) μ.
6-septate, rare, 56 by 4.5 (47 to 73 by 4 to 5) μ.
7-septate, rare, 52 by 5.5 μ.

FUSARIUM ENSIFORME Wollenweber and Reinking. Plate 2, fig. 9; text fig. 46.

Fusarium ensiforme WOLLENWEBER and REINKING, Phytopath. 15 (1925) 169.

Stroma erumpent, sclerotia rugose, often dark blue; conidia in sporodochia and in pionnotes, from whitish to golden yellow, elongate, slightly sickle-shaped, somewhat constricted at the top end, distincly pedicellate at the base, 5-, 6-, (3- to 7-) septate, 55 to 72 by 4.5 to 5 μ; 7-septate, 69 to 81 by 4.75 to 5 μ; 4-septate, 43 to 60 by 4 to 5 μ; 3-septate, 37 to 50 by 3.75 to 5 μ; in aërial mycelium also smaller, mostly unicellular, ovoid or slightly curved, 5 to 12 by 2.5 to 4 μ; chlamydospores terminal or intercalary, 1- or 2-celled, sometimes rugose, 6 to 9 μ in diameter.

Conidia may be the imperfect stage of a *Hypomyces*.

Habitat.—On decaying fruit of wild fig (*Ficus* sp.) in virgin forest. Tela, Honduras, Central America (*Reinking R 88*).

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a thin, matted, ivory yellow mycelium, possibly with patches of Lumiere blue at the base of the slant. Older cultures, up to 3 months of age, have a similar appearance, but often with a deep orient blue stroma in places. The agar in spots may have changed to dark grayish blue-green. Plate cultures 2 months old have a short, woolly, white mycelium that usually is in concentric rings. A terre-verte stroma may be present in the center of the plate.

FIG. 46. *Fusarium ensiforme* Wollenweber and Reinking; *a*, conidia from sporodochia of 14-day-old *Alnus*-stem culture; *b*, chlamydospores from 14-day-old water culture.

Oat agar.—Twenty-day-old cultures have a thick, dense felty, pale pinkish buff mycelium, occasionally with spots of blackish brown.(3) Dark delft blue sclerotia, 1 to 2 mm, are produced over the slant.

Rice.—Cultures 20 days old have a scant, white mycelium with the top of the rice turned apricot orange. Two-month-old cultures have a thin, matted, cartridge buff, apricot buff, apricot orange, and rufous mycelium. The rice is ochraceous orange and yellow ocher. Large, wartlike heaps of blackish brown(1) sclerotia may be present.

Potato-tuber plug.—Cultures 24 days old have a medium scant, white mycelium that may be in felty tufts in places and an invisible green in spots. Eight-day-old cultures are characterized by a matted, felty, cartridge buff mycelium with invisible green in places at the base.

Melilotus stem.—Twenty-day-old cultures have a medium dense, woolly, pale pinkish buff and cream buff mycelium over the stems. Small, cinnamon buff and clay color sporodochia, sometimes in masses, forming a pionnotes are produced.

Alnus stem.—Ten-day-old cultures have a medium scant, pale pinkish buff mycelium with small cinnamon buff sporodochia.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Melilotus stem; culture 10 days old; conidia from pionnotes:
Conidia—
0-septate, 3 per cent, 9 by 3.25 (6 to 12 by 2.5 to 5) μ.
1-septate, 6 per cent.
2-septate, 1 per cent.
3-septate, 22 per cent, 41 by 4 (37 to 45 by 3.75 to 4.25) μ.
4-septate, 37 per cent, 48 by 4.25 (43 to 54 by 4 to 4.5) μ.
5-septate, 31 per cent, 66 by 4.75 (60 to 72 by 4.5 to 5) μ.

Alnus stem; culture 10 days old; conidia from sporodochia:
Conidia—
3-septate, 2 per cent, 43 by 4.5 (40 to 47 by 4.25 to 5) μ.
4-septate, 4 per cent, 50 by 4.5 (44 to 56 by 4.25 to 5) μ.
5-septate, 55 per cent, 60 by 4.75 (55 to 66 by 4.5 to 5) μ.
6-septate, 37 per cent, 67 by 5 (64 to 71 by 5) μ.
7-septate, 2 per cent, 75 by 4.75 (69 to 81 by 4.75 to 5) μ.

Green bean pod; culture 12 days old; conidia from sporodochia:
Conidia—
0-septate, 32 per cent, 9 by 3 (6 to 12 by 2 to 4.5) μ.
1-septate, 8 per cent, 23 by 4 (23 to 24 by 3.5 to 4.5) μ.
2-septate, 1 per cent, 31 by 4 μ.
3-septate, 9 per cent, 47 by 4.5 (43 to 50 by 4.5 to 5) μ.
4-septate, 37 per cent, 55 by 4.5 (45 to 60 by 4 to 5) μ.
5-septate, 12 per cent, 62 by 5 (59 to 66 by 4.5 to 5) μ.
6-septate, 1 per cent, 63 by 5 μ.

Frequently on oat agar and other agars, 99 per cent of the spores are microconodia.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 11 per cent, 44 by 4.25 (37 to 50 by 3.75 to 5) μ.
4-septate, 26 per cent, 51 by 4.5 (43 to 60 by 4 to 5) μ.
5-septate, 33 per cent, 63 by 4.75 (55 to 72 by 4.5 to 5) μ.
6-septate, 13 per cent, 65 by 5 (63 to 71 by 5) μ.
7-septate, 1 per cent, 75 by 4.75 (69 to 81 by 4.75 to 5) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Hard potato agar; 23 days old:
Chlamydospores—
0-septate, in mycelium, 70 per cent, 7.25 by 7.25 (5 to 9.5 by 5 to 9.5) μ.
1-septate, in mycelium, 30 per cent, 6.25 by 11.5 (6 to 6.5 by 10.5 to 12.5) μ.

HYPOCREALES

Genus HYPOMYCES (Fries) Tul.

HYPOMYCES IPOMOEAE (Halsted) Wollenweber. Text fig. 47.

Hypomyces ipomoeae WOLLENWEBER, Phytopath. 3 (1913) 34; Journ. Agr. Research 2 (1914) 270; Ann. Myc. 15 (1917) 1–56; Angew. Bot. Zeit. f. Erf. d. Nutzpfl. 6 (1924) 300–313.

Perithecial stage.—Perithecia scattered or gregarious, free on the surface of the host as well as embedded in mycelium or on a distinct plectenchymatic stroma, ovoid, subconical, subflask-shaped; averaging 225 to 375 by 175 to 300 μ. Peridium strongly verrucose, owing to protuberancelike projections of cell groups, red to reddish brown, except the almost colorless conical beak. A few paraphyses line the inner wall of the throat from the ascus ball to the ostiolum. Asci up to over a hundred in each perithecium, intermixed with a few more-celluled paraphyses. Ascospores eight in one row, or irregularly in two rows, 2-celled, ovoid to ellipsoidal with wrinkled exospore, in mass brownish white; one septum, average size, 10 to 13 by 4.5 to 6 μ, undermoist, overripe condition slightly constricted at the septum.

Conidial stage.—Conidia scattered in sporodochia or pionnotes, of nearly cylindrical shape at the septal zone, slightly pointed and curved at the ends, base pedicellate without a distinct heel. Conidia, 3- to 5-septate; 3-septate, 30 to 45 by 3.75 to 5 μ; 5-septate, 45 to 70 by 4.25 to 5.5 μ. Of the total number, 30 per cent may be 6-septate, 10 per cent may be 7-septate, with an average size up to 70 by 6 μ. In young, moist, and hunger stages, unicellular conidia occur, averaging 6 to 12 by 3 to 4.75 μ. Color of conidia masses brownish white, occasionally impregnated with blue, a mycelium color, especially formed in the plectenchyma. Conidiophores verticillately branched. Chlamydospores globose or ellipsoidal, terminal and intercalated, mostly unicellular and scattered, average diameter, 7 to 10 μ.

Habitat.—On decaying wild plantain (*Plantago* sp.) and in the soil. Tela and Trujillo, Honduras, Central America (*Reinking R 167*).

FIG. 47. *Hypomyces ipomoeae* (Halsted) Wollenweber; *a*, conidia from mycelium of 18-day-old potato-tuber plug culture; *b*, conidia from mycelium of 9-day-old hard potato-agar culture; *c*, perithecium, × 100, from 20-day-old hard potato-agar culture; *d*, chlamydospores from 2-month-old hard potato-agar culture; *e*, ascus and ascospores from 10-day-old hard potato-agar culture.

Soil inoculations about banana plants failed to produce infection.(7)

GROWTH ON VARIOUS MEDIA

Hard potato agar.—Cultures 12 days old are characterized by a thin, matted, ivory yellow, buckthorn brown, and Dresden brown mycelium that has a stroma in concentric rings of dusky bluish green or Saccardo's slate. Few cream buff and chamois sporodochia may be present. Cultures 1 month old may have concentric rings of thin, matted, Saccardo's slate, dark grayish blue-green on pale olive buff mycelium. It may be greenish slate below with a few Russian green sporodochia. Cultures 2 months old and older are the same, but with the addition of brick red perithecia in places over the slant. Plate cultures 1 month old have a thin, white mycelium over the plate and frequently triangular stromatic patches of a dark bluish gray-green.

Potato-agar plate, 5 per cent dextrose.—One-month-old growth is characterized by a woolly, cartridge buff mycelium, possibly with hyssop violet at the edges. The mycelium in the substratum is in places dark bluish gray-green.

Note.—The somewhat variable conidial stage of *Hypomyces ipomoeae,* when isolated from different sources, fluctuates between *Fusarium theobromae* Appel and Strunk and *F. javani-*

cum Koorders, while the perfect stage in general has been found very constant in its characters.

A similar *Hypomyces,* recently collected on dead branches of an unknown tree and studied in pure culture, has been determined as *H. haematococcus* (Berkeley and Broome) Wollenweber (syn. *Nectria haematococca* Berkeley and Broome). It developed spores 12 to 13 by 5 to 6 (9 to 20 by 4 to 8) μ, slightly larger than those of *H. ipomoeae,* and conidia, 5- to 9-septate, 69 to 92 by 5.2 to 6.3 (47 to 102 by 4.5 to 7) μ, even larger and higher-septated than those in *Fusarium ensiforme* Wollenweber and Reinking, but similar in shape and color range. Perithecia occurred in pure culture at first very slowly, later on more readily, and agreed with those of the original host. This fungus will be studied further.

Oat agar.—Cultures 1 month old have a woolly, white to gray (deep gull gray) mycelium over the slant with small olivaceous black(3) sclerotia here and there. A mummy brown stromatic ring may be present at the base. Brick red or Morocco red perithecia are present.

Rice.—Cultures 20 days old have a medium growth of white, cartridge buff mycelium over the rice. In places it may be Mathews' purple and dark vinaceous purple. The rice is turned shrimp pink. Sclerotia, 3 mm in diameter and cinnamon buff, vinaceous brown, or dark vinaceous drab, are usually present. Cultures 1 month old have a matted, chestnut brown mycelium with occasional antimony yellow or Mars brown sporodochia and pionnotes masses. Cultures 2 months old may have a thin, matted mycelium that is Mars violet, cartridge buff, zinc orange, russet vinaceous, pale grayish vinaceous and on the glass ocher red or dull Indian purple. The rice remains shrimp pink.

Potato cylinder.—Cultures 23 days old have a medium dense, leathery, in places, white, cartridge buff, and grayish olive mycelium that also may be Prussian red and mummy brown where it touches the glass. It may also be dusky dull bluish green in places, and buffy olive stromatic folds may be present at the base. Cultures 2 months old have a leathery or thin papery mycelial growth that is white to gray (pale gull gray), drab and cinnamon drab in places and blackish brown(1) and possibly dusky bluish green. Brick red or Morocco red perithecia are present, often in abundance.

Melilotus stem.—Two-month-old growth has a scant white, aërial mycelium and brick red and Morocco red perithecia in abundance over the stem.

Mature corn stalk.—Cultures up to 1 month old have a scant, fluffy, white and pinkish buff mycelium.

Banana peel.—Cultures 21 days old have a scant, pale pinkish cinnamon and light pinkish cinnamon mycelium in places with pale olive or buff sporodochia.

Banana fruit flesh.—A scant white and buff pink mycelium with black, wartlike sclerotia is produced after twenty-six days of growth.

Green bean pod.—Cultures 1 month old have a medium scant, cartridge buff and cinnamon buff mycelium with cinnamon buff and dark olive buff sporodochia. Acajou red and carmine perithecia are present in 2-month-old cultures.

MEASUREMENTS OF PERITHECIA

Hard potato agar; 2 months old:
Perithecia—
375 by 315 (330 to 450 by 250 to 350) μ.

MEASUREMENTS OF ASCOSPORES

Hard potato agar; 2 months old:
Ascospores—
11 by 4.5 (9 to 14 by 4 to 5.5) μ.

MEASUREMENTS OF CONIDIA ON DIFFERENT MEDIA

Hard potato agar; culture 10 days old; conidia from sporodochia:
Conidia—
0-septate, 12 per cent, 8 by 3.25 (7 to 9 by 2.25 to 3.5) μ.
1-septate, 8 per cent, 16 by 3.75 (16 by 3.25 to 4) μ.
2-septate, 3 per cent, 22 by 4.5 μ.
3-septate, 29 per cent, 37 by 4.75 (32 to 41 by 4.5 to 5) μ.
4-septate, 22 per cent, 45 by 5 (41 to 49 by 4.5 to 5.5) μ.
5-septate, 26 per cent, 50 by 4.75 (41 to 58 by 4 to 5.5) μ.
6-septate, rare, 63 by 4.25 (60 to 65 by 4 to 4.5) μ.

Green bean pod; culture 14 days old; conidia from mycelium:
Conidia—
0-septate, 39 per cent, 8 by 3.25 (5 to 13 by 2.25 to 4.5) μ.
1-septate, 13 per cent, 18 by 4 (15 to 23 by 3.5 to 4.5) μ.
2-septate, 3 per cent, 16 by 4.25 (13 to 20 by 4 to 4.5) μ.
3-septate, 40 per cent, 29 by 4.75 (24 to 34 by 4 to 5) μ.
4-septate, 5 per cent, 36 by 5 (33 to 39 by 5) μ.

AVERAGE OF THE ABOVE MEASUREMENTS

Conidia:
3-septate, 35 per cent, 33 by 4.75 (24 to 41 by 4 to 5) μ.
4-septate, 14 per cent, 41 by 5 (33 to 49 by 4.5 to 5.5) μ.
5-septate, 13 per cent, 50 by 4.75 (41 to 58 by 4 to 5.5) μ.
6-septate, rarer, 63 by 4.25 (60 to 65 by 4 to 4.5) μ.

MEASUREMENTS OF CHLAMYDOSPORES

Hard potato agar; culture 2 months old:
Chlamydospores—
0-septate, conidial, 6.25 by 5.75 (6 to 6.5 by 5.5 to 6) μ.
1-septate, mycelial, 11 by 6.5 (8.5 to 14 by 5.5 to 8.5) μ.
0-septate, mycelial, 7 by 7 (6.5 to 8 by 6.5 to 8) μ.
1-septate, mycelial.

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ILLUSTRATIONS

PLATE 1

[Photomicrographs × 500; half-tone reproduction about × 350.]

FIG. 1. *Fusarium dimerum* Penzig; spores from mycelium and pionnotes of oatmeal-agar culture; age, 28 days.

2. *Fusarium chlamydosporum* Wollenweber and Reinking; chlamydospores, microconidium, and swellings in hyphæ from mycelium on *Melilotus* stem and in water; age, 28 days.

3. *Fusarium semitectum* Berkeley and Ravenel; spores from mycelium of oatmeal-agar culture; age, 28 days.

4. *Fusarium camptoceras* Wollenweber and Reinking; spores from mycelium of oatmeal-agar culture; age, 28 days.

5. *Fusarium bullatum* Sherbakoff var. *minus* Wollenweber and Reinking; spores from pionnotes of oatmeal-agar culture; age, 28 days.

6. *Fusarium ossicolum* (Berkeley and Curtis) Saccardo; spores from pionnotes of oatmeal-agar culture; age, 28 days.

7. *Fusarium longipes* Wollenweber and Reinking; spores from pionnotes of oatmeal-agar culture; age, 27 days.

8. *Fusarium anthophilum* (A. Braun) Wollenweber; spores from mycelium of oatmeal-agar culture; age, 28 days.

9. *Fusarium moniliforme* Sheldon; spores from mycelium and pionnotes of oatmeal-agar culture; age, 27 days.

10. *Fusarium moniliforme* Sheldon var. *erumpens* Wollenweber and Reinking; spores from sporodochia and pionnotes of *Alnus*-stem culture; age, 50 days.

11. *Fusarium moniliforme* Sheldon var. *maius* Wollenweber and Reinking; spores from sporodochia and pionnotes of *Melilotus*-stem culture; age, 52 days.

PLATE 2

[Photomicrographs × 500; half-tone reproduction about × 350.]

FIG. 1. *Fusarium fructigenum* Fries var. *maius* Wollenweber forma 1 Wollenweber and Reinking; spores from pionnotes of oatmeal-agar culture; age, 27 days.

2. *Fusarium decemcellulare* Brick; spores from large pionnotal masses of oatmeal-agar culture; age, 34 days.

3. *Fusarium macroceras* Wollenweber and Reinking; spores from pionnotes of oatmeal-agar culture; age, 23 days.

4. *Fusarium oxysporum* Schlechtendal emend. Wollenweber; macroconidia and chlamydospores; conidia from sporodochia and pionnotes of oatmeal-agar culture; age, 37 days. Chlamydospores from mycelium of oatmeal-agar culture; age, 28 days.

FIG. 5. *Fusarium oxysporum* Schlechtendal var. *nicotianae* Johnson; spores from sporodochia and pionnotes of oatmeal-agar culture; age, 50 days.

6. *Fusarium cubense* Erwin F. Smith; spores from pionnotes of *Melilotus*-stem culture; age, 12 days.

7. *Fusarium cubense* Erwin F. Smith; macroconidia, microconidia, and chlamydospores; conidia from pionnotes of *Melilotus*-stem culture; age, 12 days. Chlamydospores from mycelium of oatmeal-agar culture; age, 28 days.

8. *Fusarium alluviale* Wollenweber and Reinking; macroconidia and chlamydospores; conidia from sporodochia and pionnotes of oatmeal-agar culture; age, 50 days. Chlamydospores from mycelium of oatmeal-agar culture; age, 28 days.

9. *Fusarium ensiforme* Wollenweber and Reinking; spores from sporodochia of *Melilotus*-stem culture; age, 37 days.

PLATE 3. CULTURES OF PATHOGENIC FUSARIA ON VARIOUS MEDIA IN TEST TUBES

FIG. 1. *Fusarium cubense* Erwin F. Smith on hard potato agar; mycelium culture; age, 38 days.

2. *Fusarium cubense* Erwin F. Smith on hard potato agar; mycelium and pionnotes produced in culture; characteristic development of small blue sclerotia at the edges of growth near the base of the slant; age, 40 days.

3. *Fusarium cubense* Erwin F. Smith on hard potato agar; mycelium and mass of sporodochia, forming pionnotes, produced in culture; few small, blue sclerotia present at the base; age, 37 days.

4. *Fusarium cubense* Erwin F. Smith on potato-tuber plug; dense, leathery mycelium with small, blue sclerotia developed over potato-tuber plug; age, 136 days. Cotton in base of tube.

5. *Fusarium cubense* Erwin F. Smith on green bean pod; mycelium and pionnotes development; age, 38 days. Cotton in base of tube.

6. *Fusarium cubense* Erwin F. Smith on banana peel; mycelium, sporodochia, and pionnotes produced over the peel; age, 38 days. Cotton in base of tube.

7. *Fusarium oxysporum* Schlechtendal var. *nicotianae* Johnson on hard potato agar; mycelium and mass of sporodochia, forming a pionnotes, produced in culture; characteristic large, blue sclerotia at the base of the slant; age, 38 days.

8. *Fusarium oxysporum* Schlechtendal var. *nicotianae* Johnson on hard potato agar; mycelium culture with characteristic large, blue sclerotia at base; age, 38 days.

PLATE 4. CULTURES OF FUSARIA IN PETRI DISHES AND TEST TUBES

FIG. 1. *Fusarium cubense* Erwin F. Smith on hard potato agar; fine, fluffy, cottony, white, light buff and pale ochraceous buff mycelial growth; age, 7 days.

FIG. 2. *Fusarium martii* Appel and Wollenweber var. *minus* Sherbakoff on hard potato agar; medium coarse, short, woolly, pale pinkish buff and pinkish buff mycelium; zonation is also produced; age, 7 days.

3. *Fusarium martii* Appel and Wollenweber var. *minus* Sherbakoff on hard potato agar; medium coarse, dense, woolly, pale pinkish buff and pinkish buff mycelium; no real zonation; age, 7 days.

4. *Fusarium martii* Appel and Wollenweber var. *minus* Sherbakoff on hard potato agar; medium scant, coarse, woolly mycelium with mass of sporodochia forming a pionnotes; age, 39 days.

5. *Fusarium cubense* Erwin F. Smith on acidified hard potato agar; pure culture of fungus developing from portion of pseudostem of banana affected with wilt disease; age, 8 days.

6. *Fusarium martii* Appel and Wollenweber var. *minus* Sherbakoff on green bean pod; mycelium and pionnotes development; age, 39 days.

PLATE 5

FIGS. 1 to 4. *Calonectria rigidiuscula* (Berkeley and Broome) Saccardo; pure cultures of the fungus, isolated from partly decayed stems of *Hibiscus sabdariffae*, Buitenzorg, Java, by M. B. Schwarz, who stated that the fungus often follows *Phytophthora* stem rot. In pure culture on rice (fig. 1) the mycelium develops ocherous and carmine red plectenchymatic colors, while aërial hyphæ sometimes remain white. On oatmeal agar (fig. 2) the stroma is carmine red. Perithecia could be produced on stems of lupine and potato in a few weeks after transfer of rice-culture mycelium to these substrata. Figure 3 shows clusters of golden yellow perithecia on a lupine stem. Figure 4 shows the yellowish conidial masses developed in columns or tubercular forms at the surface of spherical or stilboidal sporodochia, scattered or in clusters, on an effuse carmine red or discolored plectenchymic stroma. Macroconidia (corresponding to *Fusarium decemcellulare*) and microconidia (*Spicaria colorans*) occur on most of the substrata used in pure cultures.

5 to 8. *Fusarium martii* Appel and Wollenweber var. *viride* Sherbakoff; pure cultures of the fungus, isolated from the soil, Tela, Honduras; fig. 5, on rice; fig. 6, on potato agar; fig. 7, on potato slant; fig. 8, on barley ear. The blue-green pionnotes develops abundantly on most of the media containing carbohydrates, but this alkaline color modification turns wine red by the addition of acids, while on rice the acid color modification develops spontaneously, turning blue by the addition of an alkali. The normal color of conidial masses is ivory yellow to brownish white, as will be seen at the upper part of the cultures of figs. 6 and 8.

PLATE 6

Fusarium moniliforme Sheldon var. *maius* Wollenweber and Reinking; pure cultures of the fungus, isolated from *Musa sapientium*, Tela, Honduras; fig. 1, on rice; fig. 2, on oatmeal agar; fig. 3, on potato tuber, showing pale orange to pale ocherous pionnotes, surrounded

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by whitish mycelium, with dark violet discoloration of the plectenchymic stroma and the substratum, beginning at the top of the tuber slice; fig. 4, older stage of the same culture as in fig. 3; fig. 5, on lupine stem, showing the powdery patches of whitish mycelium that bears the *spicaria*-like chains of microconidia, with a few sporodochia scattered over the surface of the substratum and containing macroconidia, pale orange or ocherous colored, in masses. This color range agrees fairly well with that of the other species and varieties of the section *Liseola*, as well as with that of *Gibberella moniliformis*.

TEXT FIGURES

FIG. 1. *Fusarium pusillum* Wollenweber; *a*, conidia from pionnotes of 1-month-old hard potato-agar culture; *b*, *Fusarium dimerum* Penzig; conidia and chlamydospores of 2-month-old hard potato-agar culture.

2. *Fusarium chlamydosporum* Wollenweber and Reinking; *a*, conidia from mycelium of 2-month-old hard potato-agar culture; *b*, chlamydospores in conidia and mycelium of 2-month-old hard potato-agar culture.

3. *Fusarium semitectum* Berkeley and Ravenel; *a*, conidia from mycelium of 8-day-old rice culture; *b*, conidia from mycelium of 1-month-old hard potato-agar culture; *c*, chlamydospores from 14-day-old water culture.

4. *Fusarium camptoceras* Wollenweber and Reinking; *a*, conidia, long narrow type, from mycelium of 8-day-old hard potato-agar culture; *b*, conidia, short broad type, from mycelium of 15-day-old hard potato-agar culture; *c*, chlamydospores from 15-day-old water culture; *d*, conidiophore from 12-day-old hard potato-agar culture.

5. *Fusarium incarnatum* (Robinson) Saccardo; *a*, conidia from mycelium of 1-month-old oatmeal-agar culture; *b*, conidia from mycelium of 1-month-old hard potato-agar culture; *c*, chlamydospores from 1-month-old hard potato-agar culture.

6. *Fusarium diversisporum* Sherbakoff; *a*, conidia, large, slightly curved to spindle-shaped, nonpedicellate and small, spindle-shaped, pedicellate, from mycelium of 10-day-old hard potato-agar culture; *b*, conidia, slightly curved to straight and anguiform, from pionnotes of 10-day-old oatmeal-agar culture; *c*, chlamydospores from 14-day-old water culture.

7. *Fusarium anguioides* Sherbakoff; *a*, conidia, small, narrow, slightly curved, from mycelium of 1-month-old potato-tuber plug culture; *b*, chlamydospores in conidium from 1-month-old rice culture; *c*, conidia, large and broad, nearly straight, from pionnotes of 18-day-old oatmeal-agar culture; *d*, conidia, large and broad, irregular, from pionnotes of 1-month-old rice culture.

FIG. 8. *Fusarium bullatum* Sherbakoff var. *minus* Wollenweber and Reinking; *a*, conidia from sporodochia of 14-day-old *Alnus*-stem culture; *b*, conidia from mycelium and pionnotes of 1-month-old potato-tuber plug culture.

9. *Fusarium bullatum* Sherbakoff var. *brevius* Wollenweber and Reinking; *a*, conidia from pionnotes of 8-day-old hard potato-agar culture; *b*, conidia from pionnotes of 7-day-old oatmeal-agar culture; *c*, conidia from pionnotes of 5-day-old hard potato-agar culture; *d*, conidia from pionnotes of 8-day-old *Melilotus*-stem culture.

10. *Fusarium bullatum* Sherbakoff; *a*, conidia, large, straight, non-pedicellate, from pionnotes in mycelium of 6-day-old hard potato-agar culture; *b*, conidia, smaller, pedicellate, from pionnotes and mycelium of 5-day-old hard potato-agar culture; *c*, conidia from pionnotes in mycelium of 6-day-old hard potato-agar culture; *d*, chlamydospores from 8-month-old hard potato-agar culture; *e*, conidiophore from 5-day-old hard potato-agar culture.

11. *Fusarium ossicolum* (Berkeley and Curtis) Saccardo; *a*, conidia from pionnotes of 1-month-old oatmeal-agar culture; *b*, chlamydospores, terminal and intercalary, from 1-month-old hard potato-agar culture.

12. *Fusarium falcatum* Appel and Wollenweber; *a*, conidia from sporodochia of 1-month-old *Alnus*-stem culture; *b*, conidia from pionnotes of 5-day-old hard potato-agar culture; *c*, chlamydospores from 15-day-old water culture.

13. *Fusarium acuminatum* Ellis and Everhart emend. Wollenweber; *a*, conidia from mycelium of 16-day-old oatmeal-agar culture; *b*, chlamydospores from mycelium of 2-month-old hard potato-agar culture.

14. *Fusarium caudatum* Wollenweber; *a*, conidia, long type, from sporodochia of 56-day-old rice culture; *b*, conidia from pionnotes of 15-day-old hard potato-agar culture; *c*, conidia, short type, from pionnotes of 17-day-old *Melilotus*-stem culture.

15. *Fusarium longipes* Wollenweber and Reinking; *a*, conidia, typical type, from pionnotes of 3-month-old hard potato-agar culture; *b*, conidia, short type, from pionnotes of 6-day-old hard potato-agar culture; *c*, conidia, short type, from sporodochia of 1-month-old *Alnus*-stem culture; *d*, chlamydospores from 3-month-old hard potato-agar culture and 15-day-old water culture.

16. *Fusarium anthophilum* (A. Braun) Wollenweber; *a*, conidia, long type, from pionnotes of 14-day-old oatmeal-agar culture; *b*, conidia from mycelium of 10-day-old hard potato-agar culture; *c*, conidia, short type, from pionnotes of 34-day-old rice culture; *d*, conidia and conidiophore from sporodochia of 34-day-old *Melilotus*-stem culture.

FIG. 17. *Fusarium moniliforme* Sheldon; *a*, conidia from pionnotes of one-month-old rice culture; *b*, conidia from pionnotes of 25-day-old potato-tuber plug culture; *c*, conidia from pionnotes and mycelium of 6-day-old hard potato-agar culture; *d*, conidia from sporodochia of 1-month-old *Melilotus*-stem culture; *e*, microconidia, some in chains, from mycelium of 5-day-old hard potato-agar culture; *f*, conidiophore, portion of, from mycelium of 5-day-old hard potato-agar plate culture.

18. *Fusarium moniliforme* Sheldon var. *erumpens* Wollenweber and Reinking; *a*, conidia from mycelium of 22-day-old hard potato-agar culture; *b*, early formation of sclerotial plectenchymica from mycelium in 14-day-old water culture.

19. *Fusarium moniliforme* Sheldon var. *subglutinans* Wollenweber and Reinking; *a*, conidia from pionnotes of 17-day-old hard potato-agar culture; *b*, conidia from sporodochia of 1-month-old *Melilotus*-stem culture; *c*, microconidia from mycelium of 16-day-old hard potato-agar culture; *d*, conidiophore, portion of, from mycelium of 20-day-old hard potato-agar culture.

20. *Fusarium moniliforme* Sheldon var. *maius* Wollenweber and Reinking; *a*, conidia, long, typical type, from pionnotes of 11-day-old hard potato-agar culture; *b*, conidia from sporodochia of 16-day-old *Melilotus*-stem culture; *c*, conidia from pionnotes of 11-day-old hard potato-agar culture; *d*, microconidia from pionnotes and mycelium of 11-day-old hard potato-agar culture.

21. *Fusarium neoceras* Wollenweber and Reinking; *a*, conidia from mycelium of 6-day-old hard potato-agar culture; *b*, conidia from mycelium of 20-day-old potato-tuber plug culture; *c*, macroconidia and microconidia from thin pionnotes of 37-day-old hard potato-agar culture.

22. *Fusarium fructigenum* Fries var. *maius* Wollenweber forma 1 Wollenweber and Reinking; *a*, conidia from pionnotes of 1-month-old rice culture; *b*, conidia from pionnotes of 17-day-old oatmeal-agar culture; *c*, conidia from sporodochia of 14-day-old *Melilotus*-stem culture.

23. *Fusarium decemcellulare* Brick; *a*, conidia, not typical and somewhat swollen, from pionnotes of 1-month-old green bean-pod culture; *b*, conidia, typical, from pionnotes of 4-day-old hard potato-agar culture; *c*, conidia, from sporodochia of 2-month-old hard potato-agar culture; *d*, microconidia, in chains, from mycelium of 2-month-old hard potato-agar plate culture.

24. *Fusarium macroceras* Wollenweber and Reinking; *a*, conidia, few abnormally large, from mycelium of 3-day-old oatmeal-agar culture; *b*, conidia, short and broad type, from mycelium of 2-month-old potato-tuber plug culture; *c*, conidia, typical long and slender type, from mycelium of 2-month-old hard potato-agar culture; *d*, conidia from mycelium of 19-day-old *Alnus*-stem culture.

25. *Fusarium bostrycoides* Wollenweber and Reinking; *a*, conidia from mycelium of 23-day-old hard potato-agar culture; *b*, chlamydo-

spores from mycelium of 23-day-old hard potato-agar culture; *c*, conidiophore, bostryxlike, from mycelium of 14-day-old *Melilotus*-stem culture, × 500.

FIG. 26. *Fusarium orthoceras* Appel and Wollenweber; *a*, conidia from mycelium of 15-day-old hard potato-agar culture; *b*, conidia from mycelium of 14-day-old oatmeal-agar culture; *c*, conidia from mycelium of 2-month-old potato-tuber plug culture; *d*, chlamydospores from mycelium of 2-month-old hard potato-agar culture.

27. *Fusarium orthoceras* Appel and Wollenweber var. *triseptatum* Wollenweber; *a*, conidia from mycelium of 16-day-old hard potato-agar culture; *b*, conidia from mycelium of 11-day-old hard potato-agar culture; *c*, chlamydospores from 32-day-old hard potato-agar culture; *d*, chlamydospores from 16-day-old hard potato-agar culture.

28. *Fusarium bulbigenum* Cooke and Massee; *a*, conidia from mycelium and pionnotes of 16-day-old oatmeal-agar culture; *b*, conidia from minute sporodochia of 14-day-old *Alnus*-stem culture; *c*, chlamydospores from mycelium of 15-day-old oatmeal-agar culture and from minute sporodochia of 14-day-old *Alnus*-stem culture.

29. *Fusarium oxysporum* Schlechtendal emend. Wollenweber; *a*, conidia from pionnotes of 2-month-old rice culture; *b*, conidia from pionnotes of 25-day-old hard potato-agar culture; *c*, conidia from pionnotes of 25-day-old hard potato-agar culture; *d*, conidia, short type, from sporodochia of 17-day-old *Melilotus*-stem culture; *e*, conidia from pionnotes of 23-day-old hard potato-agar culture; *f*, chlamydospores from 3-month-old green bean-pod culture.

30. *Fusarium oxysporum* Schlechtendal var. *nicotianae* Johnson; *a*, conidia, long and short types, from pionnotes of 28-day-old potato-agar culture; *b*, conidia from pionnotes of 22-day-old rice culture; *c*, conidia from pionnotes of 22-day-old *Melilotus*-stem culture; *d*, conidia from pionnotes of 22-day-old *Melilotus*-stem culture; *e*, chlamydospores from 22-day-old *Melilotus*-stem culture and 2-month-old hard potato-agar culture; *f*, conidiophore, portion, from pionnotes of 3-month-old hard potato-agar culture.

31. *Fusarium cubense* Erwin F. Smith; *a*, conidia, long, rarer type, from pionnotes of 16-day-old hard potato-agar culture; *b*, conidia, typical, shorter type, from sporodochia of 14-day-old *Melilotus*-stem culture; *c*, conidia, typical, from pionnotes of 22-day old *Melilotus*-stem culture; *d*, conidia, typical, from sporodochia of 2-month-old hard potato-agar culture; *e*, chlamydospores from conidia and mycelium of 22-day-old hard potato-agar culture; *f*, conidiophore, portion, from pionnotes of 19-day-old banana-peel culture.

32. *Fusarium aurantiacum* (Link) Saccardo emend. Wollenweber; *a*, conidia from sporodochia of 26-day-old potato-tuber plug culture; *b*, conidia from sporodochia and mycelium of 12-day-old hard potato-agar culture; *c*, chlamydospores from mycelium of 1-month-old hard potato-agar culture.

FIG. 33. *Fusarium lutulatum* Sherbakoff; *a*, conidia from pionnotes of 5-day-old hard potato-agar culture; *b*, conidia from pionnotes of 3-month-old hard potato-agar culture; *c*, chlamydospores from 3-month-old hard potato-agar culture.

34. *Fusarium solani* (Martius p. p.) Appel and Wollenweber var. *minus* Wollenweber; *a*, conidia from pionnotes of 25-day-old hard potato-agar culture; *b*, conidia from pionnotes of 15-day-old oatmeal-agar culture; *c*, conidia and chlamydospore from pionnotes of 16-day-old hard potato-agar culture.

35. *Fusarium solani* (Martius p. p.) Appel and Wollenweber var. *suffuscum* Sherbakoff; *a*, conidia from mycelium of 2-month-old hard potato-agar culture; *b*, conidia from mycelium of 1-month-old *Melilotus*-stem culture; *c*, chlamydospores from 2-month-old hard potato-agar culture; *d*, conidiophore from mycelium of 1-month-old green bean-pod culture.

36. *Fusarium solani* (Martius p. p.) Appel and Wollenweber; *a*, conidia from pionnotes of 24-day-old hard potato-agar culture; *b*, conidia from pionnotes of 3-month-old hard potato-agar culture.

37. *Fusarium alluviale* Wollenweber and Reinking; *a*, conidia from pionnotes of 25-day-old hard potato-agar culture; *b*, conidia from sporodochia of 21-day-old *Melilotus*-stem culture; *c*, conidium from pionnotes.

38. *Fusarium martii* Appel and Wollenweber var. *minus* Sherbakoff; *a*, conidia from pionnotes of 22-day-old hard potato-agar culture; *b*, conidia from pionnotes of 3-month-old hard potato-agar culture; *c*, chlamydospores from 3-month-old hard potato-agar culture; *d*, conidiophore from sporodochia of 11-day-old green bean-pod culture.

39. *Fusarium martii* Appel and Wollenweber var. *viride* Sherbakoff; *a*, conidia from pionnotes of 7-day-old hard potato-agar culture; *b*, conidia from pionnotes of 7-day-old hard potato-agar culture; *c*, chlamydospores from 21-day-old hard potato-agar culture.

40. *Fusarium martii* Appel and Wollenweber; *a*, conidia, typical, from pionnotes of 9-day-old potato-tuber plug culture; *b*, conidia, small type, from pionnotes of 23-day-old hard potato-agar culture; *c*, conidiophore from 8-day-old green bean-pod culture.

41. *Fusarium viride* (Lechm.) Wollenweber; *a*, conidia from pionnotes of 3-month-old hard potato-agar culture; *b*, conidium from sporodochia of 21-day-old *Melilotus*-stem culture; *c*, conidia from pionnotes of 15-day-old potato-tuber plug culture; *d*, chlamydospores in conidium from 3-month-old hard potato-agar culture.

42. *Fusarium radicicola* Wollenweber; *a*, conidia from pionnotes of 15-day-old rice culture; *b*, conidia and chlamydospores from pionnotes of 3-month-old hard potato-agar culture.

43. *Fusarium striatum* Sherbakoff; *a*, conidia from pionnotes of 18-day-old potato-tuber plug culture; *b*, conidia from pionnotes of 16-day-old oatmeal-agar culture; *c*, chlamydosphores from 14-day-old potato-tuber plug culture; *d*, conidiophore from mycelium of 23-day-old green bean-pod culture.

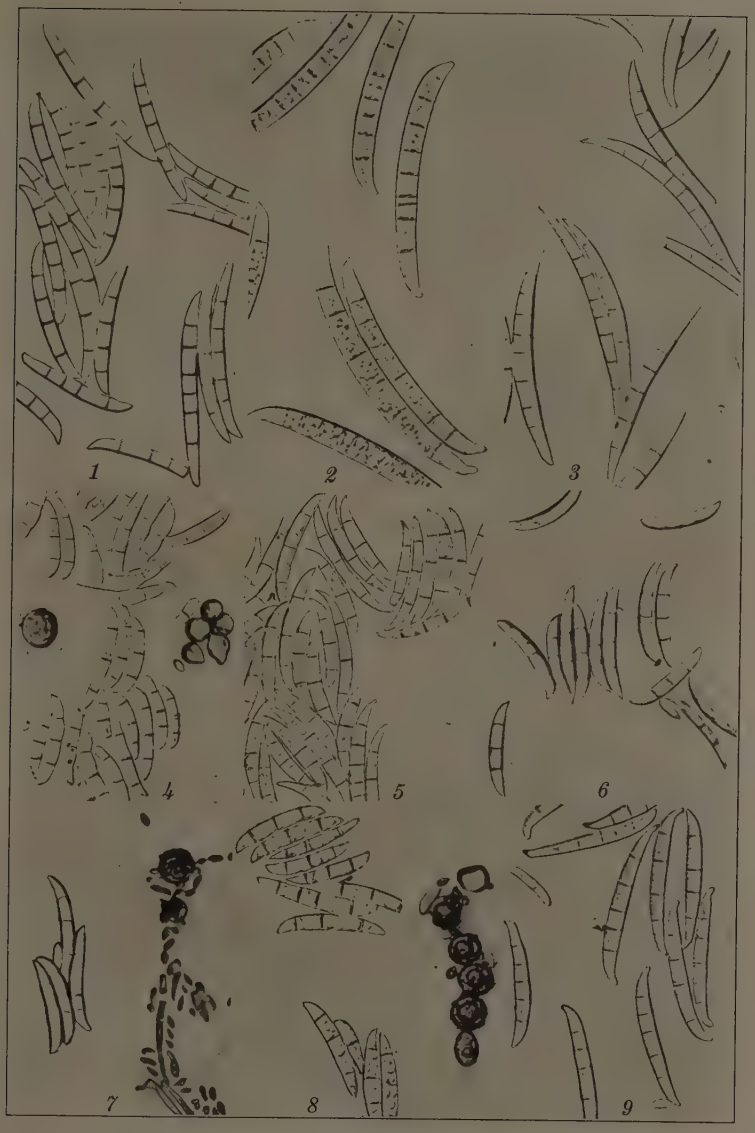
FIG. 44. *Fusarium javanicum* Koorders; *a*, conidia from pionnotes of 24-day-old hard potato-agar culture; *b*, conidia from pionnotes of 17-day-old rice culture; *c*, conidia from sporodochia of 18-day-old *Melilotus*-stem culture; *d*, chlamydospores from 16-day-old hard potato-agar culture.

45. *Fusarium theobromae* Appel and Strunk; *a*, conidia from mycelium of 1-month-old oatmeal-agar culture; *b*, conidia from mycelium of 15-day-old hard potato-agar culture; *c*, chlamydospores from 1-month-old hard potato-agar culture.

46. *Fusarium ensiforme* Wollenweber and Reinking; *a*, conidia from sporodochia of 14-day-old *Alnus*-stem culture; *b*, chlamydospores from 14-day-old water culture.

47. *Hypomyces ipomoeae* (Halsted) Wollenweber; *a*, conidia from mycelium of 18-day-old potato-tuber plug culture; *b*, conidia from mycelium of 9-day-old hard potato-agar culture; *c*, perithecium, × 100, from 20-day-old hard potato-agar culture; *d*, chlamydospores from 2-month-old hard potato-agar culture; *e*, ascus and ascospores from 10-day-old hard potato agar culture.

PLATE 1.



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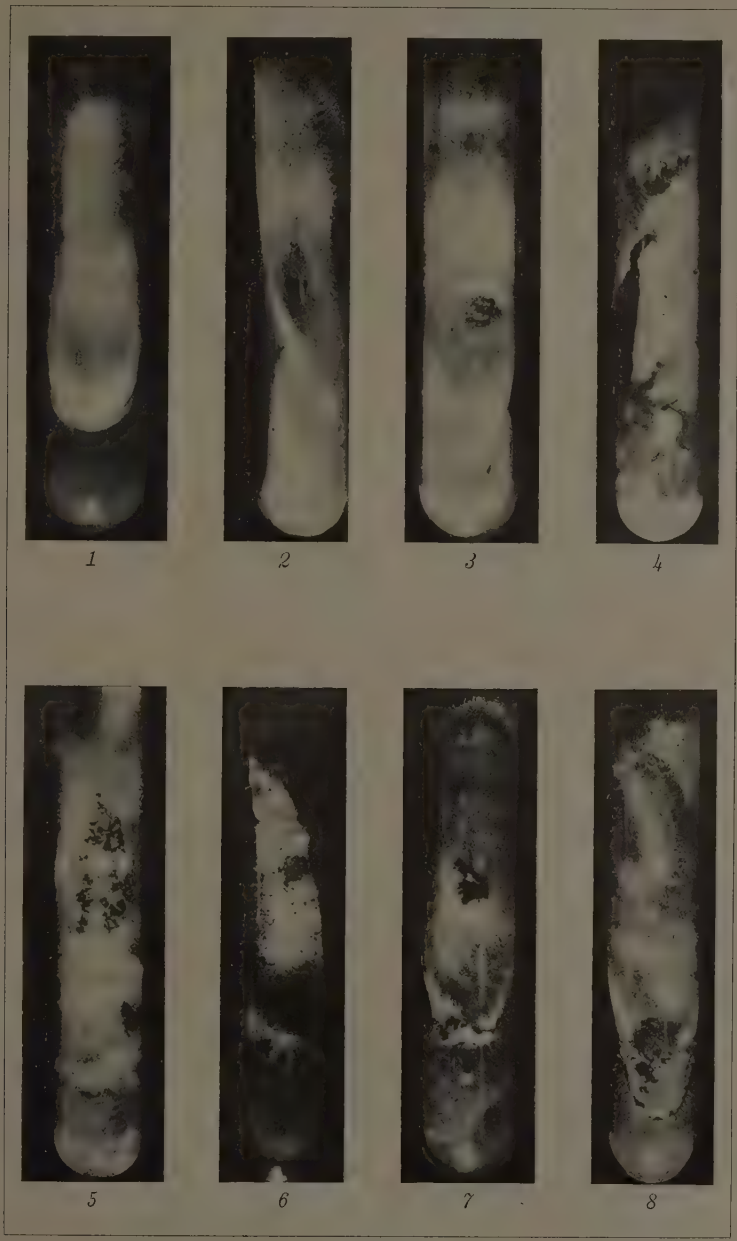

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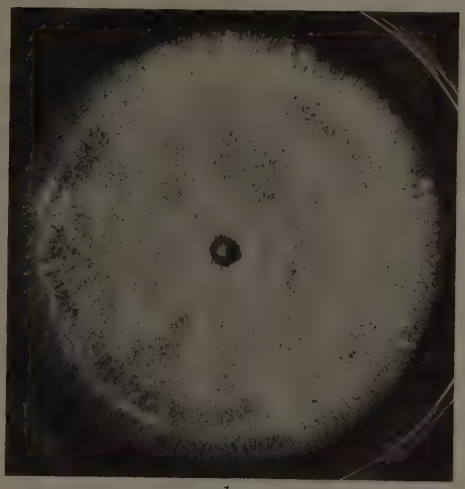

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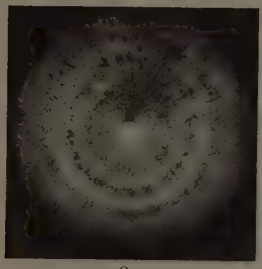

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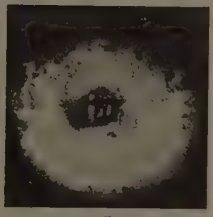

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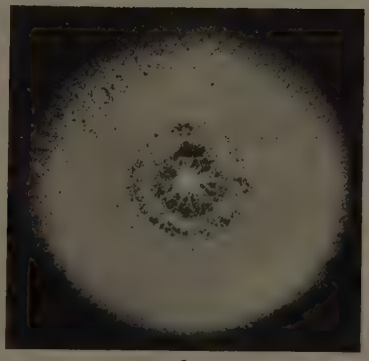

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PLATE 4.

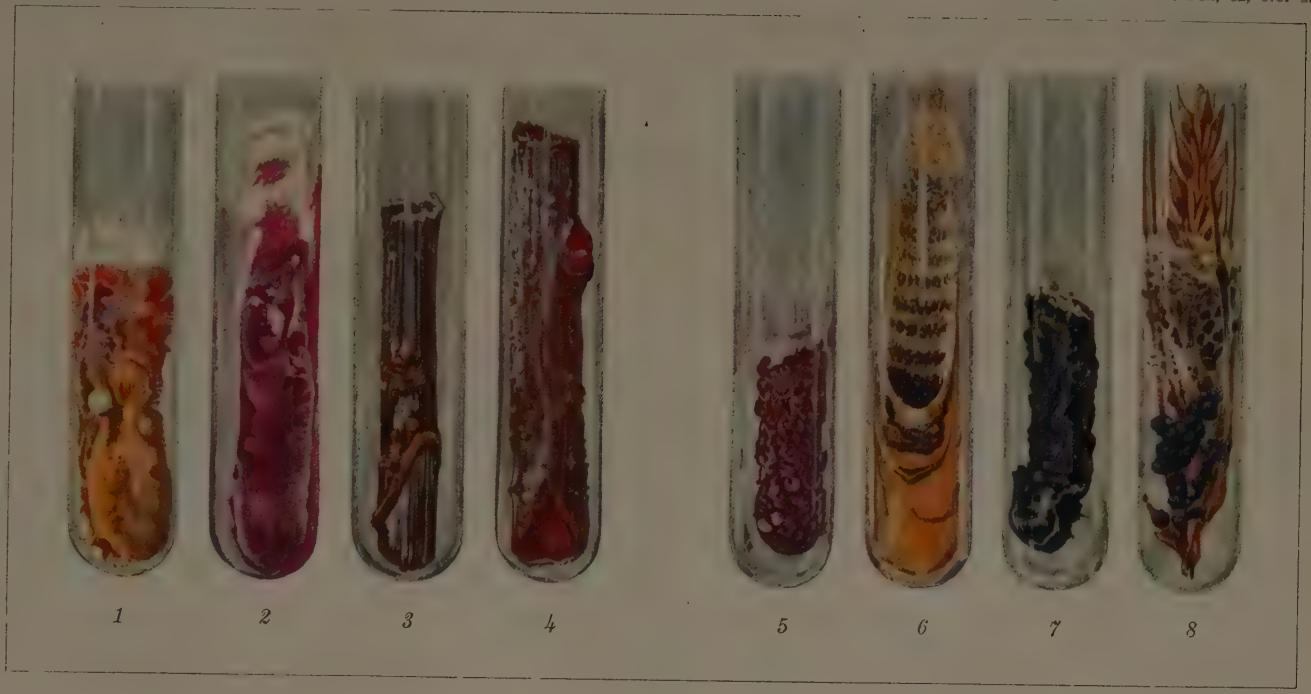

PLATE 5.

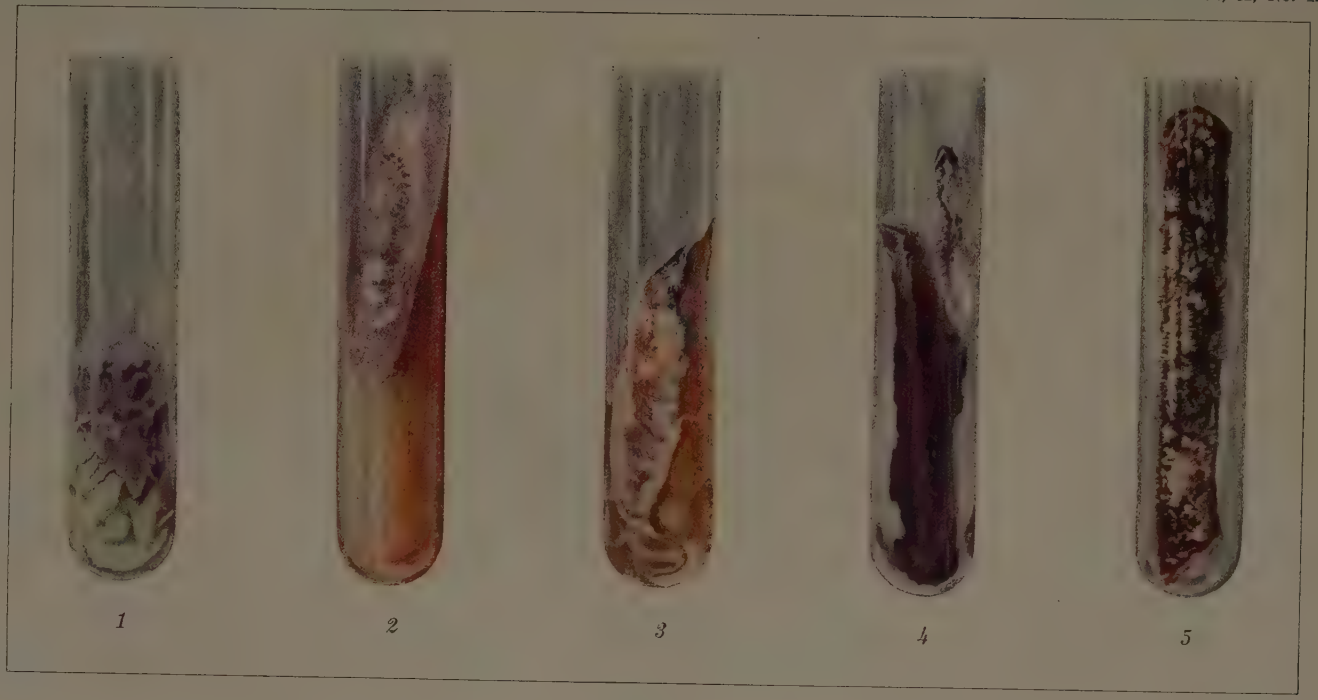

PLATE 6.

THE CALAMBAYUNGAN AND LARAP IRON-ORE DEPOSITS OF MAMBULAO, CAMARINES NORTE PROVINCE, PHILIPPINE ISLANDS

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FOUR PLATES AND TWO TEXT FIGURES

INTRODUCTION

The Calambayungan * deposits were described by W. E. Pratt.[1] At that time, however, no exploratory work whatever had been undertaken, and little was known about the size of the ore bodies occurring there. Their existence was merely indicated by the more or less frequent occurrence of ore bowlders in the surface soil, as well as by a few natural outcrops, affording little clew to the shape and persistence of the deposit. Under these circumstances it may be of interest to present here a more comprehensive account, based on the data obtained in the course of the extensive exploration work conducted by the present writer in 1923 for a large mining concern.

SITUATION AND TOPOGRAPHY

The deposits are situated in the southern part of Luzon, on the east coast of the island, about 5 kilometers (3 miles) west of the town of Mambulao, from which they are separated by Mambulao Bay. The locality lies 185 kilometers (115 miles) in a straight line about east by south of Manila. Mambulao, which is a town of about 2,000 inhabitants, has weekly communication with Manila by the through express train between this place and Hondagua, a port at Lopez Bay on the east coast, about 65 kilometers (36 miles) southwest of Mambulao. From Hondagua a steamer, connecting with the express train, runs once a week along the coast eastward, one of its ports of

* This name is spelled Calambayanga in the Census of the Philippine Islands and on Coast and Geodetic Survey charts. People living in the vicinity of the island call it Calambayuñgan.—EDITORS.

[1] Philip. Journ. Sci. § A 10 (1915) 323–331.

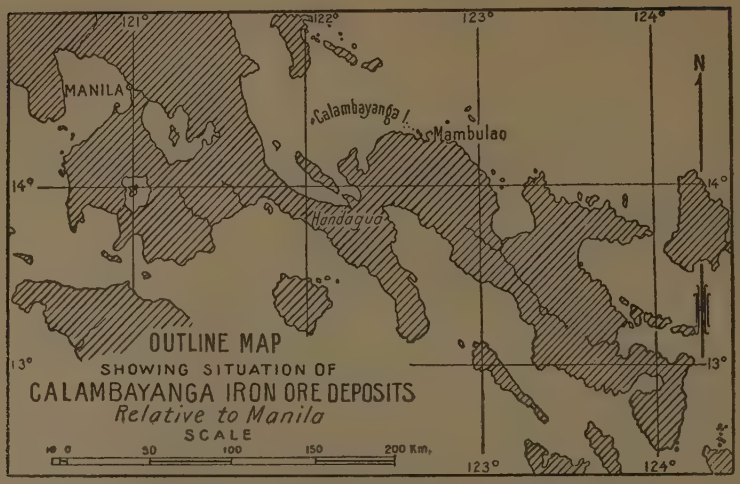


FIG. 1. Southern Luzon, showing the location of the Mambulao region.

call being Mambulao. The whole trip can be made in less than twenty-four hours. By the sailing route around southeastern Luzon the distance from Manila to Mambulao is about 900 kilometers (500 miles).

The deposits occupy parts of Larap Peninsula and Calambayungan Island; the latter is separated from the former by a shallow channel, about 40 meters (1,300 feet) broad. Off the northwest point of the island the sea has a depth of 5 to 7 fathoms (10 to 13 meters) within a distance from the shore of less than 200 meters (600 feet), and a pier could be easily constructed to this deep-water edge. On the other hand, the coast is rather open, but a breakwater, comparatively inexpensive, would provide sufficient protection, except during occasional typhoons, when loading vessels would have to run for shelter to the nearest typhoon harbors. For small vessels Dahikan Bay, a few kilometers west of Calambayungan Island, is a sufficiently safe harbor, while larger vessels would have to take refuge in a bay about 80 kilometers east of Mambulao. Under the present system of notification a vessel can always be advised of dangerous weather twenty-four hours ahead, providing ample time for precautions.

Most of the rainfall occurs from October to March, inclusive, when the northeast monsoon from the sea carries abundant humidity, while the months of April to September, when calm weather and winds from other directions prevail, are compar-

FIG. 2. The Mambulao region.

atively dry. Hence the latter season would offer favorable conditions for shipping. Table 1 has been compiled from the weather reports regarding Legaspi, which is the observation station nearest to Mambulao.

TABLE 1.—*Showing wind percentages for one year at Legaspi.*

Wind from—	Percentage, June to October.	Percentage, November to May.	Percentage for entire year.
(a)	29	14	20
North	6	24	16
Northeast	15	47	34
East	6	11	9
Southeast	1	0	1
South	6	1	2
Southwest	27	2	13
West	9	1	4
Northwest	1	0	1
	100	100	100

[a] Calm.

From Table 1 it will be seen that it is calm during 20 per cent of the year, while the wind blows from the north or northwest (the only unprotected directions) for 17 per cent of the time. The other 63 per cent of the time the wind blows from directions against which there is shelter. This would seem to indicate 83 per cent of "working weather" during the year. In a similar way it may be figured out that there should be 93 per cent of "working weather" during the five-month period, June to October (inclusive), while during the rest of the year there should be about 76 per cent of "working weather."[2]

The whole region is heavily forested. Only small patches along the shores have been cleared to give place to coco groves or banana and abacá plantations, and hence the district can be traversed only along certain trails cut through the tropical jungle of shrubbery and dense cordlike creepers. Trees of valuable hardwood, many of them of large size, grow abundantly and would yield an ample supply of timber for railroad sleepers, trestles, piers, etc. On the other hand, the clearing off of the iron-ore hills, previous to exploitation of the deposits, would not offer any great difficulties, as the undergrowth could be easily burned during the dry season.

[2] These data regarding weather conditions have been compiled and kindly communicated by Judge Frank B. Ingersoll.

Camarines Norte Province occupies the northernmost part of the Southeastern Cordillera. Hence the region is hilly, with altitudes up to 1,000 meters (3,280 feet).

Larap Peninsula consists of a hill ridge, extending north and south for a distance of about 2.5 kilometers (more than 8,200 feet) with a maximum elevation of about 100 meters (330 feet) in its southern portion and gradually lowering toward the north. Its eastern flank dips rather steeply into the bay, while on the western side there is a flat-lying strip of land between the shore and the base of the ridge. In the shallow water along the beach there is a more or less continuous fringe of mangrove swamps.

The channel between the point of the peninsula and Calambayungan Island—which may be said to form a continuation of the Larap ridge—is shallow, at most 1.5 fathoms (2.7 meters) deep. The bottom consists of a hard and rather even coral reef, on which a railway trestle could easily be laid to connect the peninsula with the deep water off the northwestern shore of the island. The ridge on the island traverses its northwestern portion, where the summit has an elevation of about 65 meters (210 feet) above the sea level, while the southeastern portion is lower and partly level, thus offering a suitable site for a mining town. The local fresh-water supply on the island would probably be insufficient for a large settlement, but on the eastern shore of Mambulao Bay there are several creeks of adequate size from which the water could be conveyed by pipe lines across the bay.

HISTORICAL NOTES

Pieces of iron slag found near Mambulao indicate the existence during some period in the past of a primitive iron industry, utilizing the ore of Calambayungan or Larap. Neither local tradition nor official documents seem to give any accurate information regarding this extinct iron-smelting industry. It is only recorded that during the Spanish control of the Philippines concessions for iron mines on Calambayungan Island were repeatedly sought. On the other hand, it is known that the iron ores farther north in the Luzon cordillera were exploited in the seventeenth and eighteenth centuries. Probably the Mambulao deposits were discovered at a similarly early date, since gold mining is known to have been carried on for three centuries in this region.

In modern times the Mambulao deposits attracted the interest of A. C. Cavender, a mining engineer who had been for many years engaged in gold mining in the same district. Later Mr. Joaquin Casanovas became associated with him.

In 1918 Cavender and Casanovas leased their holdings on Calambayungan Island to a Japanese company, which planned to ship ore to Japan for smelting in blast furnaces in that country.

A wooden pier, about 100 meters long, was built from the beach toward the deep water's edge and a narrow-gauge railroad track was laid down southward along the base of the western slope. Ordinary bench-quarrying methods were used, but most of the output was obtained from bowlders and rubble occurring in the superficial clay.[3] The ore was delivered by means of wooden chutes to the lower benches on the railroad, where it was loaded into hand cars to be dumped into scows at the pier. The company is stated to have employed 300 to 500 men and the daily output at times reached 100 to 150 tons. However, in 1919 the mining operations were suspended, owing to the cessation of the war boom; the Japanese engineers and "bosses" left the place, and the mining property was restored to its owners. The total shipment of iron ore is stated to have been 48,000 tons. As already mentioned, most of this ore was derived from surface bowlders and no systematic prospecting and development was done by the Japanese leaseholders.

EXPLORATORY WORK

On Larap Peninsula the deposits of iron ore are found within the boundaries of four patented mining claims known as the Busser, Superior, Bessemer, and Rescue claims, which have a combined area of 192 hectares.

On Calambayungan Island the deposits are confined to the northern half of the island, an area of about 35 hectares.

A large mining concern that was investigating the Mambulao deposits did a considerable amount of exploratory trenching work, both on Larap Peninsula and on Calambayungan Island, in 1923. The organization and superintendence of this work was entrusted to Mr. E. A. Heise, an American who, for eighteen years, had traveled extensively in the Islands, engaged in gold prospecting, dredging, and mining, and who thus possessed a very thorough and valuable experience in such work.

[3] Min. Resources P. I. for 1917–1918 (1920) 25.

Thanks to his energetic efforts the work, which was begun about the first of March, proceeded rapidly, effectively, and smoothly and was brought to a conclusion in the middle of August.

The workers were selected exclusively from among the local inhabitants, and the number varied from fifty to one hundred. The population of Mambulao, having previously subsisted mainly on the gold-mining industry, had been hard hit by the cessation of this industry a few years before and the men were eager to avail themselves of this opportunity for temporary employment. In Mr. Heise's opinion, it would not have been difficult to get at least two hundred good laborers from among the local population; and, by drawing on the available labor in the surrounding districts, a supply in excess of the requisite number for exploiting the ore deposits on a commercial scale could probably be secured.

The efficiency of the picked men employed for the exploratory work seemed to be quite satisfactory; indeed, they worked hard from 5 a. m. until 5 p. m. with scarcely an hour's intermission for the midday meal. As shown by the subjoined tables, a considerable amount of work was performed. However, as already intimated, these men were picked, and an increase in the number to several hundred would most likely entail a lowering of the standard.

The scale of wages for all kinds of labor in the Philippine Islands is comparatively high, for ordinary labor roughly three times as high as in China, one peso being the usual daily wage. This was also the price paid to the workmen employed for the exploratory work.

The trenches were dug, with an interval of about 100 meters (330 feet), at right angles to the trend of the ridge and with an average width of from 1.2 to 1.3 meters (4 to 4.5 feet). From the bottom of these trenches square vertical test pits were sunk, at certain intervals, as deep as possible. The soft surface clay and the almost equally soft, decomposed country rocks could be excavated by pick and shovel only, while most of the ore had to be blasted by dynamite. The walls of the trenches and pits, on the whole, stand well. That, nevertheless, considerable trouble was experienced from caving in was due to the abnormal amount of rainfall during what should have been the dry season.

Altogether twenty-two trenches were cut across the Larap ridge; in addition five minor stray trenches were dug, four of

which were intended to serve as assessment work on the original claims Nos. 5 and 6. The fifth trench is a small one, located on the eastern flank of the ridge, between the Busser and the Superior claims. The aggregate length of the Larap trenches amounts to about 1,500 meters (5,000 feet), and the average depth to about 1.8 meters (6 feet). As mentioned above, the width is roughly 1.2 meters. Hence the total volume of these excavations amounts to about 3,400 cubic meters or, say, 116,000 cubic feet. From the bottom of the trenches one hundred eight pits were sunk, with an average depth of 3.7 meters (maximum 7.5 meters) and a total volume of more than 600 cubic meters or, say, 22,000 cubic feet.

On the island, nine trenches were cut, with an aggregate length of 585 meters (1,920 feet), an average depth of 1.7 meters (6 feet), and a volume of 1,300 cubic meters (46,000 cubic feet). There are fifty-nine pits, with an average depth of 3.1 meters (10 feet) and a total volume of 270 cubic meters (9,500 cubic feet).

The details for each trench are given in Table 2 which should be confronted with the vertical sections on Plate 2.

GEOLOGY AND ORE DEPOSITS

According to the geologists of the Philippine Bureau of Science [4] the Eastern Cordillera is a complex of pre-Tertiary igneous rocks on which has been deposited a younger sedimentary series. The whole complex has been tilted, largely metamorphosed, and intruded by dikes of basic composition (diorite, diabase, gabbro, partly with porphyritic texture) and overspread by flows of agglomerates (andesite). The upper beds are tuffs, clays, and sands of Pleistocene to Recent age, while the lower part of the series is made up of shales, sandstones, arkoses, and limestones, assigned to the Miocene and Oligocene.

The iron ore is found at the base of the sedimentaries, near their contact with the underlying igneous basement. At Larap and Calambayungan the sedimentary rocks consist of sandstones, conglomerates, shales, tuffs, and minor limestone intercalations. The whole series has a general trend north and

[4] See W. E. Pratt, Philip. Journ. Sci. § A 10 (1915) 323–331; and Min. Resources P. I. for 1913 (1914) 21–31. *Also* W. D. Smith, Philip. Journ. Sci. § A 8 (1913) 235; and Min. Resources P. I. for 1909 (1910) 33.

south, with local variations up to north 40° west, and dips uniformly westward at varying angles. Near the ore deposit, the rocks—both igneous and sedimentary—have been thoroughly decomposed, largely forming a soft, clayey mass, the original nature of which cannot be determined.

TABLE 2.—*Showing details of trenches.*

LARAP PENINSULA.

Designation.	Trench.			Pits.		
	Length.	Average depth.	Volume.	Number.	Average depth. [a]	Volume.
	m.	*m.*	*cu. m.*		*m.*	*cu. m.*
H¹	40	1.6	73	0	0	0
G¹	50+43	1.0	120	0	0	0
F¹	130	1.7	220	4	2.5	15
E¹	114	1.6	236	2	2.0	6
1	32+60	1.8	214	6	3.0	27
2	104	2.0	270	10	3.9	58
3	31+36	1.6	139	6	3.0	27
4	47	1.5	91	5	3.0	23
5	30+19	1.9	121	8	3.0	36
6	90	1.9	222	8	2.8	34
7	118	2.1	321	10	5.0	75
8	113	1.9	278	12	5.0	90
9	39	1.5	75	4	3.5	21
10	52	2.0	135	6	3.5	31
11	46	2.0	119	3	4.3	19
12	39	2.0	101	3	4.8	22
13	42	2.2	119	3	3.8	17
14	18+24	1.7	92	5	5.0	38
15	61	2.0	158	7	5.3	56
16	39	2.4	93	5	4.4	33
17	44	2.2	124	0	0	0
18	30	2.0	75	1	7.0	9
Total and average	1,491	1.8	3,396	108	3.7	637

CALAMBAYUNGAN ISLAND.

A	40	2.0	104	6	3.5	32
B	48	1.5	93	5	3.4	25
D	58	1.5	113	8	3.5	42
E	28	1.7	61	3	2.3	10
F	105	1.8	245	10	2.2	33
G	72	2.2	295	9	3.3	44
H	49	1.8	114	6	4.2	38
I	118	1.7	260	6	3.0	27
K	67	1.4	120	6	2.3	21
Total and average	585	1.7	1,315	59	3.1	272

[a] The depth of the pits has been reckoned from the bottom of the trenches, not from the surface.

The ore-bearing strata extend from the northwestern point of Calambayungan Island toward the south and southwest, across the highest portion of the island, to the vicinity of its southwestern shore. Across the gulf between the island and the northern point of Larap Peninsula there is an interruption of about 0.8 kilometer (2,600 feet) after which the ore zone can be traced southward along the central ridge, to the southern end of the peninsula. The total distance from the northwestern point of the island to the southern termination of the iron-bearing zone is about 3.5 kilometers (2.2 miles).

Of this total extent of the iron-bearing formation, about 750 meters (2,460 feet) belong to the island, while on the peninsula the ore bodies cover a length of about 2,150 meters (7,050 feet). Outside of this main iron-bearing belt, there is, on the western side, a minor area cropping out on an islet.

Again, at Batobolani, about 10 kilometers (6 miles) southeast of Larap and also near the line of contact between the sedimentaries and the older igneous rocks, there is a similar outcrop.

Due to the fact that the iron ore is harder, much less decomposed, and much less easily eroded than the associated rocks, its outcrops stand out in prominent relief so that the iron-ore belt forms the backbone of the whole ridge. This is a great advantage from the mining point of view, rendering the ore bodies much more easily accessible.

As is illustrated by the map, the ore does not occur as a continuous layer along the whole extent of the iron-bearing belt but forms detached bodies, separated by barren intervals. The shape of these bodies is irregularly tabular or lenticular; sometimes they swell out to a considerable width, sometimes they taper abruptly and pinch out. This peculiarity seems not only to apply to their extent on the surface; the same feature also appears on the cross sections. The latter show, moreover, that the dip is gently to the west, its angle in a general way conforming with the dip of the encasing sedimentary strata. Since this angle is, as a rule, slightly larger than the grade of the western flank of the ridge, it follows that the amount of overburden will probably increase somewhat toward the base of the ridge.

From the mode of occurrence indicated above it may be reasonably presumed that the extent of the ore bodies along the dip is roughly equidimensional with their horizontal length, and that the irregularities shown by the plan and the sections will

be repeated in a similar way in the deeper portions of the ore bodies not yet exposed.

In addition to this solid ore in place, there is a not inconsiderable amount of ore occurring as subangular bowlders and pebbles scattered over the surface and embedded in the residual surface clay on the flanks of the ridge and along the beach. Certain areas, marked approximately on the map, are littered with such ore bowlders and their abundance may, at first sight, induce one to believe that solid ore is to be found in place underneath. As amply proved by the trenching work performed, however, this is not the case. On closer inspection, it appears that they are surficial accumulations of exactly the same kind as those connected with the iron-ore deposits in the lower Yangtse Valley in China.[5] These bowlder accumulations are evidently the result of an intense differential weathering and erosion, leaving the hard and heavy ore comparatively intact, and preferably removing the encasing soft and light sedimentaries. In their present position the bowlder accumulations seem to be derived partly from the big outcrops on the crest of the ridge, wherefrom they have been detached and have gradually slidden downward during the process of erosion and waste-creep; partly they seem to be remnants of minor nests, originally inclosed in the sedimentaries near the spot where they are now found.

CHARACTER OF THE ORE

The iron ore of the Larap and Calambayungan deposits consists of nearly pure hematite, with a very subordinate intermixture of gangue matter. The hematite is partly hard and crystalline, partly soft and rather friable. It is rather dense-grained but at the same time porous and vesicular. Quartz is the commonest and most uniformly distributed gangue matter; it seems to fill the interstices between the hematite individuals, and it also forms druses lining small vugs and veinlets in the ore mass. Occasionally even rock crystals of considerable size (70 centimeters in length) have been found. On an average, however, the percentage of quartz hardly exceeds 3 per cent. Pyrite, in the shape of small specks and lumps, is occasionally though sparsely encountered. Green copper stains, resulting from the weathering of such pyrite, indicate that the latter is somewhat cupriferous. Frequently there are specks of a whit-

[5] See the present writer's work, Iron Ores and Iron Industry of China, Memoirs Geol. Survey of China, Ser. A. (1921–1924) No. 2.

ish, clayey substance in the ore. In the rich ore this substance occurs only very sparsely, but in the somewhat poorer grades which form the transition between the ore body and the encasing clay-shale, this substance forms streaks and fragments of considerable size. The ore is very low in phosphorus, and this element seldom exceeds the Bessemer limit.

Surfaces of the ore long exposed to rain and wind exhibit a peculiar polished, but at the same time irregularly pitted, appearance, evidently due to the leaching out of softer portions of the ore.

A number of samples collected under my supervision have been assayed in the laboratory of the Kailan Mining Administration at Tongshan, China. The results are given in Table 3.

GENESIS OF THE ORE

In general character and habit the ore in these deposits strikingly resembles the ores of the Yangtse Valley, already referred to, which are beyond doubt of contact-metamorphic and metasomatic origin. The likeness also extends to many features relating to the shape and mode of occurrence of the deposits. These facts strongly suggest a similar origin for the Mambulao deposits, although the scarcity of outcrops prohibits a closer study of the relationships between the ore and the as-

TABLE 3.—*Showing assay of ore samples from Calambayungan and from Larap Peninsula.*

CALAMBAYUNGAN ISLAND.

Sample from—	Insoluble in hydrochloric acid (HCl).	Silicon oxide (SiO_2).	Iron (Fe).
	Per cent.	*Per cent.*	*Per cent.*
Trench A, bottom and walls of trench	3.00	2.45	63.75
Trench A, pits	6.60	6.45	60.74
Trench B, bottom and walls of trench	2.10	1.90	64.92
Trench B, pits			
Trench D, bottom and walls of trench	2.90	2.70	64.64
Trench D, pits	9.10	8.50	60.79
Trench F, bottom and walls of trench	2.45	2.25	65.43
Trench F, pits	4.50	4.10	64.15
Trench G, bottom and walls of trench	2.05	1.75	63.87
Trench G, pits	5.10	4.00	62.19
Trench H, bottom and walls of trench	1.45	1.30	65.10
Trench H, pits	2.00	1.50	64.32
Trench I, bottom and walls of trench	2.25	2.00	64.99
Trench K, pits	1.40	1.20	66.82
Average	3.45	3.08	63.94

TABLE 3.—*Showing assay of ore samples from Calambayungan and from Larap Peninsula*—Continued.

LARAP PENINSULA.

Main ore body:			
Trench 1, bottom and walls of trench	11.27	8.10	53.77
Trench 1, pits	3.20	2.85	63.60
Trench 2, bottom and walls of trench	3.57	3.35	63.40
Trench 2, pits	6.60	5.95	59.00
Trench 3, bottom and walls of trench	2.40	2.21	64.41
Trench 3, pits	3.77	3.20	63.00
Trench 4, bottom and walls of trench	4.75	4.35	62.39
Trench 4, pits	4.27	3.60	63.54
Trench 5, bottom and walls of trench	5.62	4.97	61.44
Trench 5, pits	3.45	2.80	62.10
Trench 6, bottom and walls of trench	1.20	1.10	64.80
Trench 6, pits	1.65	1.40	63.60
Trench 7, bottom and walls of trench	1.00	0.90	66.54
Trench 7, pits	1.00	0.90	64.65
Trench 8, bottom and walls of trench	3.05	2.75	62.06
Trench 8, pits	4.25	3.75	59.53
Trench 9, bottom and walls of trench	3.12	2.81	62.35
Trench 9, pits	2.70	2.40	64.15
Average	3.70	3.19	62.45
Minor ore bodies:			
Trench 10, bottom and walls of trench	7.77	6.82	55.34
Trench 10, pits	7.30	5.45	60.11
Trench 13, bottom and walls of trench	2.22	1.99	64.83
Trench 13, pits	3.25	2.50	63.43
Trench 15, bottom and walls of trench	5.32	4.10	60.62
Trench 15, pits	7.15	6.20	59.94
Trenches 17 and 18, bottom and walls of trench	14.25	11.75	55.39
Trench 17, pits	8.20	6.75	59.11
Average	6.93	5.69	59.84

sociated rocks. That the seemingly massive ore has originated by replacement of a preëxisting bedded rock is seen in some outcrops, where the weathering has revealed, and partly sculptured out, the bedding structure of the original rock. The source of the iron-bearing solutions, that dissolved and substituted certain, probably calcareous, strata in the sedimentary series, cannot be determined with certainty; but Pratt's supposition, that this mineralization was effected by later emanations from the same igneous source as that from which the volcanic dike rocks are derived, seems plausible. The gold-bearing quartz veins are also related to the same dike rocks.

ESTIMATE OF ORE RESOURCES

We may exclude from this estimate the two minor ore bodies in the southern part of Larap Peninsula, because of their re-

mote situation and somewhat inferior quality. Hence we only figure on the main ore body, extending between trenches 1 and 9. This ore body is approximately 700 meters long, while along the dip, westward and downward, it may reasonably be expected to extend to the base of the hill, a distance of 250 to 300 meters on the average. However, only the upper portion may be considered as ore in sight. Therefore, it seems advisable to include in the calculation only the upper 100 meters, although, no doubt, there are additional resources in the lower portion of the western flank.

TABLE 4.—*Complete analyses of mixtures of all the samples in equal proportions.*

	Larap Peninsula.	Calambayungan Peninsula.
	Per cent.	*Per cent.*
Loss by calcination	3.59	3.02
Silicon dioxide (SiO_2)	3.51	2.97
Aluminium oxide (Al_2O_3)	3.58	2.80
Titanium oxide (TiO_2)	None	None
Ferric oxide (Fe_2O_3)	87.34	89.51
Ferrous oxide (FeO)	1.53	1.60
Manganese oxide (MnO_2)	0.20	0.22
Calcium oxide (CaO)	0.19	0.26
Magnesium oxide (MgO)	Traces	Traces
Barium oxide (BaO)	0.065	0.014
Phosphorus pentoxide (P_2O_5)	0.20	0.09
Sulphur trioxide (SO_3)	0.22	0.44
Total	100.425	100.924
Metallic iron (Fe)	62.30	63.88
Phosphorus (P)	0.09	0.04
Sulphur (S)	0.09	0.18

Turning to the island, it is to be noted that out of the total length of the iron-bearing formations—750 meters—only about 480 meters, or roughly 60 per cent, actually contain ore, while the remaining 270 meters are barren, at least as far as the test pits and trenches reach. In computing the amount of ore it may reasonably be assumed that the same proportion between ore bodies and barren intervals also obtains in the direction of the dip. It is also to be expected that the extension in the latter direction of the ore formation as a whole, including ore bodies and barren intervals, will be roughly equidimensional with the horizontal extent, and that hence it is fairly safe to assume that the ore formation will continue undiminished as

far as the base of the hill at the western shore of the island. This distance, from the crest of the ridge to the western shore, is only about 170 meters on the average. Since, however, the lower portion of this strip of the ore formation may be buried underneath too thick an overburden of rocks and soil to be easily workable, only the uppermost 100 meters will here be taken into account.

The average thickness of the ore, as measured on the sections, is given in Table 5.

TABLE 5.—*Average thickness of iron-ore bodies.*

Section.	Meters.
Larap Peninsula.	
1	7.0
2	3.5
3	7.0
4	10.0 (?)
5	18.0
6	6.0
7	5.0
8	5.0
9	4.5
Average	7.3
Calambayungan Island.	
A	5.0
D	5.5
F	4.0
G	5.0
H	7.0
I	3.5
K	3.5
Average	4.8

Applying the principles and data set forth in the foregoing, the easily available resources can be computed as shown in Table 6, the specific gravity being taken as 4.0.

TABLE 6.—*Estimate of the Larap and Calambayungan iron-ore deposits.*

	Larap Peninsula.	Calambayungan Island.
Length of iron formation.....meters..	700	480
Lateral extent along the dip.....do....	100	100
Average thickness of ore.....do....	7.3	4.8
Volume of ore.....cubic meters..	511,000	230,000
Tonnage.....	2,040,000	920,000

In addition to these easily available resources, it may be possible to obtain considerable quantities from deeper levels; but these cannot be estimated until additional evidence regarding the dimensions of the ore bodies at deeper levels has been obtained by borings.

Appreciable quantities of ore can also be obtained from the surface bowlders, already referred to. The amount, however, is not easily calculable owing to the irregularly scattered occurrence of these bowlders. Some data bearing on the proportion of bowlders in the surface soil have been obtained in the course of the trenching work. These are given in Table 7.

TABLE 7.—*Estimate of iron-ore bowlders.*

Designation of trench.	Length.	Width.	Depth.	Volume.	Volume of bowlders.	Bowlders in soil.
	m.	*m.*	*m.*	*cu. m.*	*cu. m.*	*Per cent.*
Larap:						
1	15	1.3	1.7	33.1	3.0	9
1	12.4	1.3	1.7	27.4	14.9	55
1	47	1.3	1.5	91.6	30.0	33
2	34	1.3	1.8	79.6	27.2	34
2	19	1.3	2.2	54.3	19.0	35
9	22	1.3	2.0	57.2	5.6	10
Average						29
Calambayungan Island:						
A	20	1.3	2.0	52.0	13.0	25
G	12	1.3	2.2	34.0	5.8	17
H	15	1.3	1.5	29.0	14.5	50
H	11.7	1.3	2.0	30.0	12.0	40
I	18	1.3	1.7	28.7	14.5	50
I	24.5	1.3	1.7	54.1	4.8	9
I	34	1.3	1.0	44.2	3.4	8
K	19.5	1.3	1.6	40.4	8.2	20
K	24.0	1.3	1.3	40.6	4.8	12
Average						26

From Table 7 it is seen that, in the surface layers near the crest of the ridge, through which the trenches have been cut, the percentage of bowlders varies within very wide limits, the average being 29 per cent for the Larap Peninsula and 26 per cent for the Calambayungan Island. These figures, however, are probably too high to be applied directly to the whole of the bowlder areas, since the frequency seems to be considerably greater near the outcrop zone along the crest than farther down on the flanks. Very likely 15 to 20 per cent will prove to be nearer the mark.

Owing to the dense vegetation, the tracing of the extent of the various bowlder areas offers considerable difficulty. Moreover, the thickness of the ore-bearing clay can, for the most part, only be conjectured. Table 8 records the results of an attempt to arrive at an estimate of the minimum amount available.

TABLE 8.—*Estimate of bowlders.*

Bowlder area.	Area.	Depth.	Volume of soil mass.	Bowlders.	Volume of bowlders.
	sq. m.	*m.*	*cu. m.*	*Per cent.*	*cu. m.*
Larap, Superior	[a] 6,400	1	6,400	15	960
Larap, Busser	[a] 5,000	1	5,000	15	750
Do	[b] 20,000	2	40,000	20	8,000
Do	[c] 20,000	1	20,000	15	3,000
Calambayungan Island	20,000	1	20,000	15	3,000
Total					15,710

[a] Beach. [b] Along the eastern slope. [c] Along the western slope.

Multiplying the volume of the bowlders, 15,710 cubic meters, by the specific gravity, 4, we arrive at a total of about 60,000 tons. It must, however, be pointed out that the depth (or thickness) of the ore-bearing clay layer seems to be highly variable, so that no reliable average figure can be stated. The figures here assumed are safe minima; and, therefore, it may well happen that the actual amount of ore contained in the bowlder deposits will turn out to be double the estimated amount, or more.

ILLUSTRATIONS

PLATE 1

Map of the Larap and Calambayungan iron-ore deposits.

PLATE 2

Cross sections of the Larap and Calambayungan iron-ore deposits. A to K, Calambayungan Island; 1 to 15, Larap Peninsula.

PLATE 3

FIG. 1. Large bowlders of iron ore. Northwest point of Calambayungan Island.

2. Rock of solid iron ore, showing on weathered surface the original bedding of replaced sedimentaries.

PLATE 4

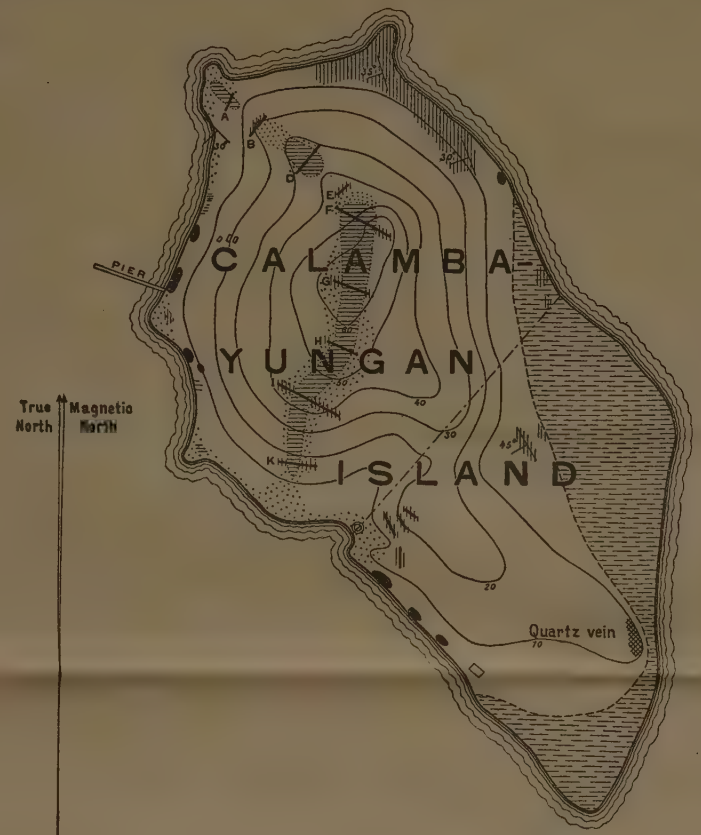
FIG. 1. A steep cliff of iron ore at trench 5, on the eastern flank of Larap ridge.

FIGS. 2 and 3. Trenches with test pits, on Larap Peninsula.

TEXT FIGURES

FIG. 1. Map of southern Luzon, showing the location of the Mambulao region.

2. Map of the Mambulao region, after the United States Coast and Geodetic Survey.



MAP
OF
THE IRON ORE DEPOSITS
OF

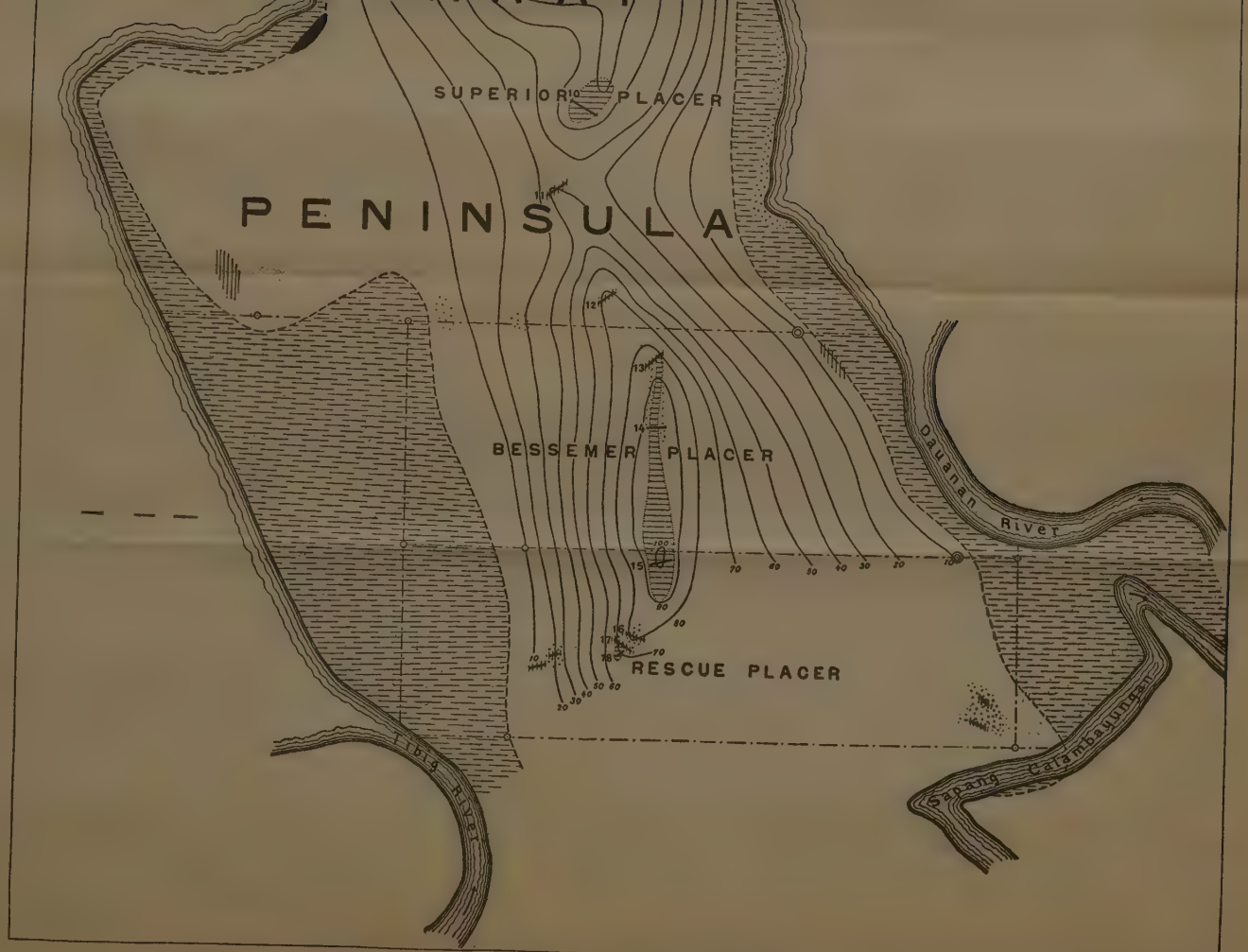
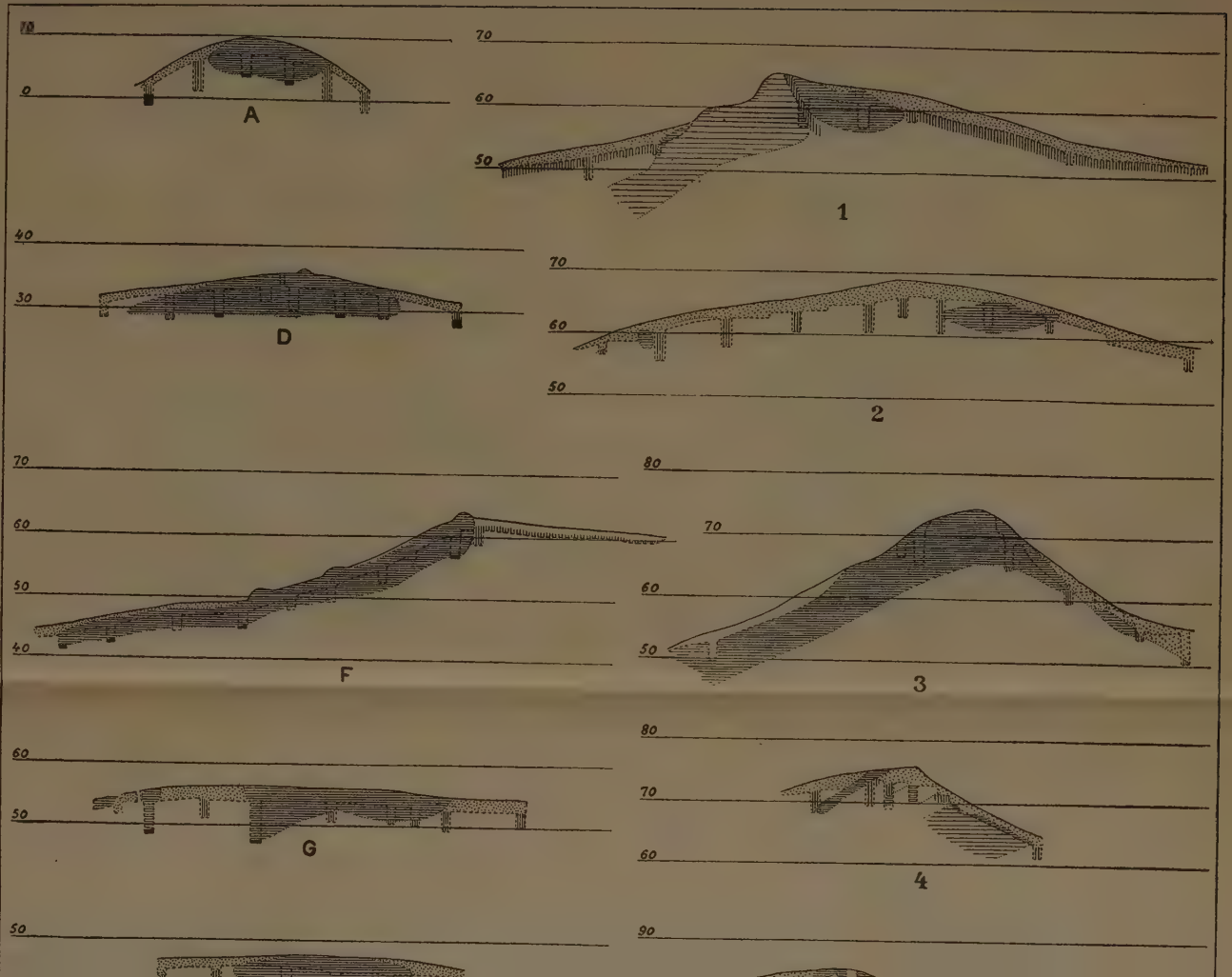
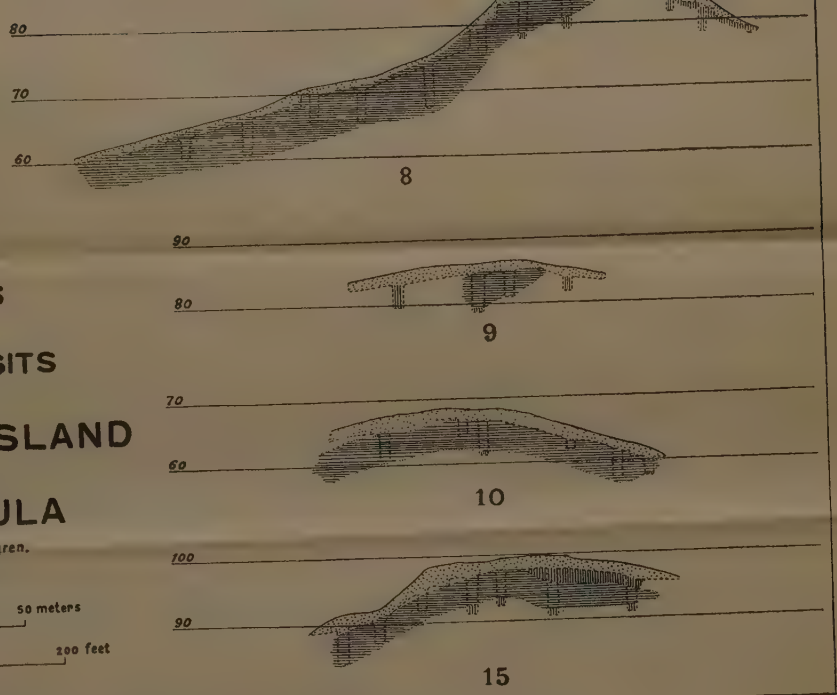


PLATE 1. LARAP PENINSULA AND CALAMBAYUNGAN ISLAND, SHOWING LOCATION OF THE IRON-ORE DEPOSITS.


10
0
A
70
60
50
1
40
30
D
70
60
50
2
70
60
50
40
F
80
70
60
50
3
60
50
G
80
70
60
4
50
90

A to K Calambayungan Island
I to 15 Larap Peninsula

N.B. On all the sections
West is to the left and
East to the right.



CROSS SECTIONS
OF
THE IRON ORE DEPOSITS
OF
CALAMBAYUNGAN ISLAND
AND
LARAP PENINSULA

Surveyed in August 1923 by F. R. Tegengren.

Scale 1:1000

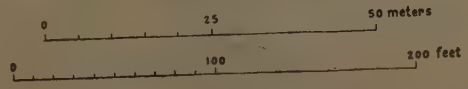
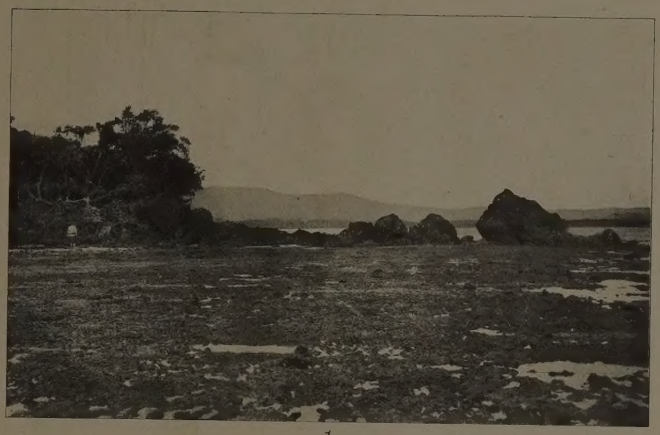


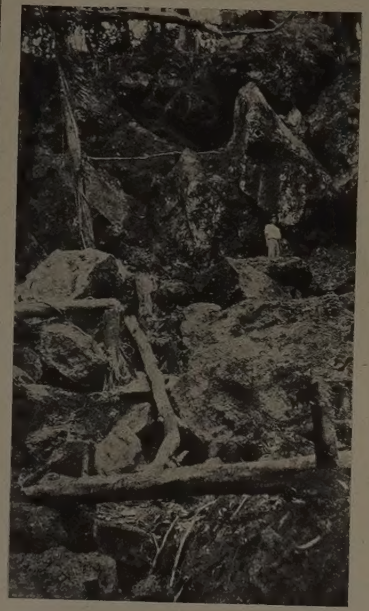
PLATE 2. CROSS SECTIONS OF THE LARAP AND CALAMBAYUNGAN IRON-ORE DEPOSITS.



1

2

PLATE 3.



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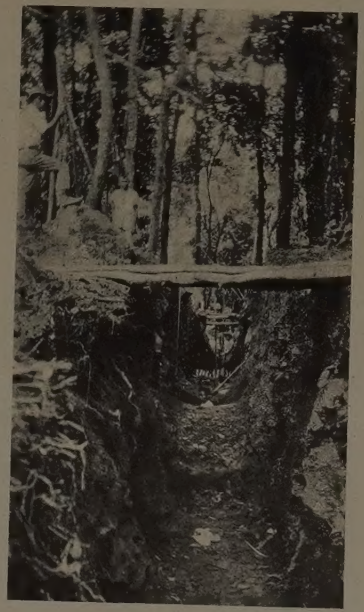

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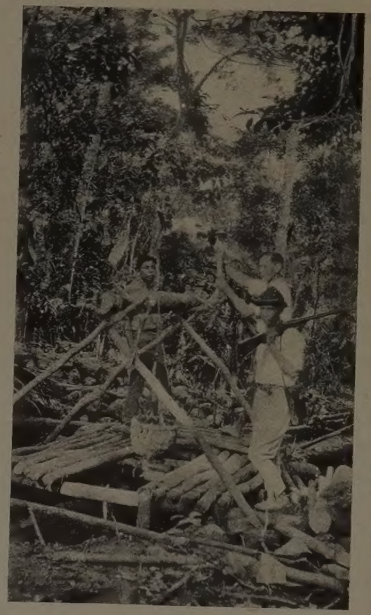

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PLATE 4.